ADDENDUM
FEASIBILITY STUDY
FORMER MANUFACTURING PLANT AREA
SHERWIN-WILLIAMS/HILLIARDS CREEK SITE

GIBBSBORO, CAMDEN COUNTY, NEW JERSEY
ADMINISTRATIVE ORDER INDEX NO. II CERCLA-02-99-2035

Prepared for:

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EXECUTIVE SUMMARY

Pursuant to Administrative Order on Consent (AOC) Index No. II CERCLA-02-99-2035, The Sherwin-Williams Company (Sherwin-Williams) on January 11, 2019 submitted to the United States Environmental Protection Agency Region 2 (EPA) the Feasibility Study for soil at the Former Manufacturing Plant (the FMP FS) area of the Sherwin-Williams/Hilliards Creek Site, located in Gibbsboro, Camden County, New Jersey. Following EPA review and presentation to the Regional Remedy Review Board, the EPA provided comments to Sherwin-Williams in a letter dated March 11, 2019. Sherwin-Williams met with EPA on March 14, 2019 to discuss the comments. On March 28, 2019, EPA issued a letter to Sherwin-Williams (received April 9, 2019) requiring that an additional alternative for soil be evaluated. This addendum to the FMP FS describes and evaluates the additional remedial alternative.

EPA's March 28, 2019 letter states:

> "*EPA is directing Sherwin-Williams to include an additional soil alternative (based on what is already proposed for excavation within Soil Alternative 3) that will address soil contamination (currently proposed for being capped) for areas both north and south of Foster Avenue (west of Hilliards Creek, in the vicinity of the 7 Foster avenue structure). The remedial alternative to be included for this area is to address soil contamination, which exceeds NJDEP's Residential Direct Contact Soil Remediation Standards (RDCSRS), down to a depth of 4 feet.*"

The EPA letter further states:

> "*The additional soil alternative which EPA is directing Sherwin-Williams to present in the revised FS, should maintain the elements that address the light non-aqueous phase liquid (LNAPL) contamination that are currently present in Soil Alternative 3, as well as maintain the current remedial alternative for the Former Lagoon area contamination.*"

The objective of this FS addendum is to describe and evaluate the EPA-directed alternative (Soil Alternative 3A) against the other soil alternatives presented in the FMP FS. This FS addendum is intended to be reviewed along with the information included in the January 11, 2019 FS (FMP FS), including the Remedial Action Objectives (RAOs), the Applicable or Relevant and Appropriate Requirements (ARARs), and the summary of site conditions presented in the FS.

Soil Alternative 3A is evaluated according to seven criteria set forth in the National Contingency Plan (NCP). Based on the evaluation of alternatives presented in the FS and this addendum, the EPA will present alternatives, as well as the preferred remedy, in a Proposed Plan. Following a period of public comment on the Proposed Plan, the EPA will consider two other criteria and issue a Record of Decision (ROD) finalizing selection of the remedy for the FMP.

FORMER MAIN PLANT SOIL ALTERNATIVE 3A

Soil Alternative 3A – Soil and LNAPL Removal/Treatment, Capping with Supplemental Excavation, and Institutional Controls – consists of all of the actions for Soil Alternative 3 (see FMP FS), but adds an additional excavation component in the Main Plant Area. This additional excavation would consist of a removal of up to four feet in the parking area of the 7 Foster Avenue building, located south of Foster Avenue and west of Hilliards Creek, and up to a four foot removal in the parking area west of the 2 and 4 Foster Avenue buildings and beneath the 6 East Clementon Road building slab.

EVALUATION OF SOIL ALTERNATIVES

Soil Alternatives 3, 3A and 4 fully meet the two threshold criteria of "Protection of Public Health and the Environment" and "Compliance with ARARs". All of the alternatives protect human and ecological receptors from direct contact exposure to constituents in soil, prevent transport of contaminated soil in surface water, remove sources of groundwater contamination, remove or contain LNAPL to the extent practicable and prevent risks due to soil vapors.

Soil Alternatives 3, 3A and 4 also score highly for the balancing criterion "Long-Term Effectiveness and Permanence", since all will provide long-term protection of public health and the environment. Soil Alternatives 3A and 4 score slightly higher than Soil Alternative 3 for this criterion because they do not rely solely on the impermeable cap in the Main Plant Area to prevent exposure to constituents in soil at concentrations greater than the RDCSRS.

Soil Alternative 4 ranks lower than Soil Alternatives 3 and 3A in the balancing criterion "Reduction of Toxicity, Mobility and Volume Through Treatment", because Alternative 4 would physically remove the vast majority of the LNAPL, but no treatment would occur. Alternatives 3 and 3A would stimulate the already robust biological degradation of the LNAPL, reducing its toxicity, mobility and volume through biological treatment.

Although Alternatives 3, 3A and 4 all have significant Short-term Effectiveness and Implementability issues, Alternative 3A ranks lower than Alternative 3, and Alternative 4 ranks lower than Alternative 3A in these balancing criteria:

- Implementation of Soil Alternative 3A would require 27,000 CY (38,000 tons) more soil to be removed than would Soil Alternative 3. All of this soil would be from the Main Plant Area. This would require another 3,800 truck trips (a total of 10,800) to remove contaminated soil and bring in clean backfill. All of the additional trucks would need to use Foster Avenue to access either U.S. Avenue or Clementon Road, both two lane roads with residences on them.

  Alternative 3A would require almost a year and a half more to complete than Alternative 3, and all of this additional time would be in the FMP Main Plant Area. This would potentially interfere with the ability to use the buildings in this area for over a year and a half.

  Soil Alternative 3A would also result in potential short-term impacts to the structures and occupants of the 7 Foster Avenue and 10 Foster Avenue buildings. There is a potential for structural damage when the excavation is conducted around the entire perimeter of the building. There is also a potential for damage to any underground utilities that may be present. Occupants in the building may not have safe access to the building during construction activities, and, if they do have access, they will be subject to construction impacts such as noise and truck traffic.

- Implementation of Soil Alternative 4 would require that almost eight times as much soil be removed from the Site than would be required under Soil Alternative 3 and four times as much soil be removed from the Site than would be required under Soil Alternative 3A. This translates to approximately 38,000 more truck trips through the community to remove soil and import backfill than Soil Alternative 3 and 34,000 more truck trips that Soil Alternative 3A. Soil Alternative 4 would require four additional years to complete than Soil Alternative 3, and approximately two and a half more years than Soil Alternative 3A, resulting in a longer period of impacts to the community. Excavation depths for Soil Alternative 4 are much greater than those for Soil Alternatives 3 and 3A, creating potential risks to U.S. Avenue and Foster Avenue during construction. The extensive excavation that would be required under Soil Alternative 4 would also place at risk the workers conducting the remedial action.

Soil Alternative 3 ranks higher for the balancing criterion of "Implementability" than does Soil Alternative 3A, and Soil Alternative 3A ranks higher than Soil Alternative 4.

- The issues that create the greater Short-Term Effectiveness issues for Soil Alternative 3A than compared to Soil Alternative 3 are those that also create the greater Implementability difficulties. More soil will be removed, and more parking areas will need to be reconstructed. An excavation of up to four feet will be conducted in the parking areas immediately adjacent to the 7 Foster and 10 Foster Avenue buildings. Therefore, there will be a need to install measures to ensure that the buildings are not damaged, and to implement procedures to either relocate the building occupants during construction or provide safe access to the buildings.

- The Implementability issues for Soil Alternative 4 are much greater than either Soil Alternative 3 or 3A because of the very large volume of soil that would be removed and the depths of the removal. The depths of the excavations that would be conducted under Soil Alternative 4 would result in the need to install substantial soil stability measures to protect roadways and workers, manage much larger volumes of contaminated groundwater and stabilize larger volumes of saturated soil prior to transport.

Soil Alternative 3 ranks higher for cost ($24 million) than Soil Alternative 3A ($31 million), which ranks higher that Soil Alternative 4 ($87 million).

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ACO	Administrative Consent Order
AOC	Administrative Order on Consent
ARAR	Applicable or Relevant and Appropriate Requirement
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COC	contaminant of concern
COPC	contaminant of potential concern
CY	cubic yard
EPA	United States Environmental Protection Agency
EPH	extractable petroleum hydrocarbons
FMP	Former Manufacturing Plant
FPR	free product recovery
FS	Feasibility Study
gph	gallons per hour
gpm	gallons per minute
HHRA	Human Health Risk Assessment
IGWSRS	Impact to Groundwater Soil Remediation Standard
Kg	kilogram
L	liter
LNAPL	Light Non-Aqueous Phase Liquid
mg	milligram
NCP	National Contingency Plan
NJDEP	New Jersey Department of Environmental Protection
NPL	National Priorities List
NRDCSRS	Non-Residential Direct Contact Soil Remediation Standard
O&M	operations and maintenance
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyls

PCP	pentachlorophenol
PDI	Pre-Design Investigation
PID	photoionization detector
PP	Proposed Plan
PRG	Preliminary Remediation Goal
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RDCSRS	Residential Direct Contact Soil Remediation Standard
RI	Remedial Investigation
RIR	Remedial Investigation Report
ROD	Record of Decision
Sherwin-Williams	The Sherwin-Williams Company
SVOC	semi-volatile organic compound
TBC	To Be Considered
TSCA	Toxic Substances Control Act
U.S.	United States
µg	microgram
XRF	X-Ray Fluorescence

1.0 INTRODUCTION

Pursuant to Administrative Order on Consent (AOC) Index No. II CERCLA-02-99-2035, The Sherwin-Williams Company (Sherwin-Williams) submitted to the United States Environmental Protection Agency Region 2 (EPA) on January 11, 2019 the Feasibility Study (FS) for soil, sediment and surface water at the Former Manufacturing Plant (FMP) area of the Sherwin-Williams/Hilliards Creek Site (Hilliards Creek Site) located in Gibbsboro, Camden County, New Jersey (Figure 1). The FMP FS followed the *"Remedial Investigation Report, Soil, Sediment, Surface Water, Pore Water and Vapor Intrusion, Sherwin-Williams Hilliards Creek Superfund Site, Former Manufacturing Plant Area"* (FMP RIR) (Weston, 2018). The FMP area became part of the Hilliards Creek Site in 2007, and the Hilliards Creek Site was listed on the National Priorities List (NPL) in 2008.

Following review of the FMP FS, EPA provided comments on March 11, 2019. In Appendix A is a response to these comments. Sherwin-Williams met with EPA on March 14, 2019 to discuss the comments. On April 9, 2019, Sherwin-Williams received from EPA a letter dated March 28, 2019 requiring the inclusion of an additional soil alternative to the FMP FS.

EPA's March 28, 2019 letter states:

> "*EPA is directing Sherwin-Williams to include an additional soil alternative (based on what is already proposed for excavation within Soil Alternative 3) that will address soil contamination (currently proposed for being capped) for areas both north and south of Foster Avenue (west of Hilliards Creek, in the vicinity of the 7 Foster Avenue structure). The remedial alternative to be included for this area is to address soil contamination, which exceeds NJDEP's Residential Direct Contact Soil Remediation Standards (RDCSRS), down to a depth of 4 feet.*"

The EPA letter further states:

"*The additional soil alternative which EPA is directing Sherwin-Williams to present in the revised FS, should maintain the elements that address the light non-aqueous phase liquid (LNAPL) contamination that are currently present in Soil Alternative 3, as well as maintain the current remedial alternative for the Former Lagoon area contamination.*"

The FMP FS described and performed a comparative analysis of four soil remediation alternatives:

- Soil Alternative 1 – No Action
- Soil Alternative 2 - Targeted Surface Soil Removal, Capping and Institutional Controls
- Soil Alternative 3 – Soil and LNAPL Removal/Treatment, Capping and Institutional Controls
- Soil Alternative 4 – Extensive Excavation to Depth and Institutional Controls

This FS addendum adds the alternative directed by EPA. Soil Alternative 3A, "*Soil and LNAPL Removal/Treatment, Capping with Supplemental Excavation, and Institutional Controls"*, consists of all of Soil Alternative 3, but adds an excavation component surrounding the 7 Foster Avenue building, located south of Foster Avenue and west of Hilliards Creek, and in the parking area west of the 2 and 4 Foster Avenue buildings, extending beneath the 6 East Clementon Road building slab, north of Foster Avenue. As directed by EPA, under Soil Alternative 3A the additional excavation would extend to the shallower of four feet or the depth at which the RDCSRS are achieved in those areas where excavation was not already proposed for another reason.

In support of the comparative analysis in the FMP FS, a substantial amount of information was provided, including:

1. A description of the site and its environmental setting, and a summary of the history of the site;

2. The nature and extent to which constituents are present in soil as presented in the FMP Remedial Investigation Report (RIR);

3. The potential human health risks based on the Human Health Risk Assessment (HHRA);

4. The potential ecological risks based on the Baseline Ecological Risk Assessment (BERA);

5. Technology screening for potential application at the FMP;

6. Remedial Action Objectives (RAOs) for soil, sediment and surface water;

7. Applicable or Relevant and Appropriate Requirements (ARARs) for the site;

8. Detailed descriptions of the four original soil alternatives, including the actions needed to complete them and their estimated costs.

This information is incorporated into this FS addendum by reference. It is repeated only as necessary to support the comparative analysis of Soil Alternative 3A with the soil alternatives presented in the FMP FS. For example, as presented below, the criteria by which the soil alternatives are evaluated are provided for context for the comparative analysis.

This FS addendum is presented in the following sections:

- Section 2 describes the criteria used to conduct the comparative analysis of the soil alternatives.

- Section 3 describes Soil Alternative 3A.

- Section 4 provides the comparative analysis of the soil remedial alternatives.

2.0 SOIL ALTERNATIVE 3A EVALUATION CRITERIA

EPA guidance specifies nine criteria against which each alternative is to be evaluated. The modifying criteria (see below) will be evaluated by EPA following public comment. Therefore, this analysis evaluates Soil Alternative 3A against seven evaluation criteria.

In order for an alternative to be selected by EPA as the preferred remedy, two criteria, categorized as "Threshold Criteria", must be met. The two threshold criteria are:

1. Overall protection of human health and the environment: The assessment of this criterion describes how the remedial alternative, as a whole, achieves and maintains protection of human health and the environment.

2. Compliance with ARARs: The assessment of this criterion evaluates how each of the remedial alternatives complies with ARARs, or if an ARAR waiver is required and how it is justified.

The other five criteria are termed "Balancing Criteria," and are the criteria upon which the comparative analysis of alternatives is based (EPA, 1988a). These criteria are:

1. Long-term Effectiveness and Permanence: The assessment of this criterion evaluates the long-term effectiveness of a remedial alternative in maintaining protection of human health and the environment after the response objectives have been met.

2. Reduction of Toxicity, Mobility and Volume Through Treatment: The assessment of this criterion evaluates whether treatment is employed and, if so, the expected

performance of the specific treatment technologies employed in the alternative in eliminating or reducing the residual toxicity, mobility and volume of wastes.

3. Short-term Effectiveness: The assessment of this criterion evaluates the effectiveness of each alternative in protecting human health and the environment during the construction and implementation of a remedy until the remedial objectives have been met. This criterion includes evaluation of the risks and impacts of remedy implementation.

4. Implementability: The assessment of this criterion evaluates the technical and administrative feasibility of each alternative and the availability of required goods and services.

5. Cost: The assessment of this criterion evaluates the capital, operation and maintenance (O&M), and total project present-worth costs of each alternative.

The final two of the nine criteria are "Modifying Criteria" and are evaluated by EPA following comments on the proposed plan and are addressed when the ROD is being prepared. The modifying criteria are:

1. State Acceptance: This assessment considers the State's (or support agency's) apparent preferences among, or concerns about, the alternatives.

2. Community Acceptance: This assessment considers the community's apparent preferences among, or concerns about, the alternatives.

3.0 SOIL ALTERNATIVE 3A – SOIL AND LNAPL REMOVAL/TREATMENT, CAPPING WITH SUPPLEMENTAL EXCAVATION, AND INSTITUTIONAL CONTROLS

Descriptions of Soil Alternatives 1, 2, 3 and 4 for each of the FMP remedial units (Figure 2) are provided in the FMP FS. Soil Alternative 3A would consist of the following actions (Figure 3):

Former Main Plant Area

- Remove the soil that is the source of arsenic found in groundwater north of Foster Avenue.

- Remove soil containing PCBs at concentrations greater than 50 mg/kg (the concentration at which the PCBs become defined as a PCB remediation waste under TSCA) at locations adjacent to the Silver Lake conveyance north of Foster Avenue.

- Remove up to four feet of soil beneath the former 6 E Clementon Road building slab, the parking area west of the 2 and 4 Foster Avenue buildings, and the 7 Foster Avenue building parking area. The excavation will extend to the shallower of four feet or where the RDCSRS are achieved.

- Install an impermeable cap in those areas where soil removal was conducted if constituents remain in the unsaturated zone at a concentration greater than the Impact to Groundwater Soil Cleanup Standards (IGWSRS). For purposes of this FS, it is assumed that the impermeable caps currently in place would be replaced.

- Address any underground structures that may be a source of contamination.

Former Resin Plant/Tank Farm A Area

- Maintain the existing impermeable cap and soil cover.

- Evaluate the need to remove the arsenic present beneath the soil cover at a concentration greater than the IGWSRS.

- Install a LNAPL recovery system in the 2 and 4 Foster Avenue buildings.

- Install a system to deliver sulfate, nitrate and/or other nutrients to the LNAPL across the Former Resin Plant/Tank Farm A area to stimulate the existing LNAPL biodegradation.

- Install a system to remove methane and other soil gas generated by the biodegradation of the LNAPL from the subsurface.

- Address any underground structures that may be a source of contamination.

<u>Seep Area</u>

- Remove soil containing LNAPL from the Seep Area to an approximate depth of five to seven feet.

- Restore the excavation area and reinstall the parking area.

- Install a collection trench south of Foster Avenue to prevent LNAPL transport under Foster Avenue from the Former Resin Plant/Tank Farm A area to the Seep Area and Upper Hilliards Creek.

<u>Former Lagoon Area</u>

- Remove soil to a depth of approximately 8 feet bgs in two locations in the former Lagoon Area to address the source of pentachlorophenol in groundwater.

- Develop a site-specific IGWSRS for pentachlorophenol to support an evaluation of the need to remove any additional unsaturated soil where pentachlorophenol is present at concentrations greater than the default IGWSRS. The information needed to develop the site-specific IGWSRS would be collected as part of a PDI.

- Restore the excavation areas and maintain the existing soil cap that is present across the remainder of the former Lagoon Area.

- Conduct additional characterization within the Former Lagoon Area to identify the source of VOC/SVOC TICs in groundwater. It is expected that the results of this evaluation would be used to develop and evaluate remedial alternatives for the VOC and SVOC TICs in the groundwater FS.

Upper Hilliards Creek

- Remove all soil containing constituents greater than the PRGs in the top one foot of the Upper Hilliards Creek floodplain.

- Remove all soil at depths greater than one foot where constituents are present at concentrations greater than the RDCSRS throughout the Upper Hilliards Creek floodplain.

In all areas, a groundwater monitoring network would be installed following implementation of the remedial action.

Former Main Plant Area

Based on the existing data, excavations totaling over 35,000 CY of soil would be conducted in four areas of the Main Plant area north of Foster Avenue:

- An excavation ranging from 10 to 15 feet bgs would be conducted beneath and adjacent to the 6 East Clementon Road building slab to remove the arsenic that is a source to groundwater. As part of the excavation, portions of the building slab would need to be removed.

- A six-foot excavation would be conducted at the southeastern corner of the 10 Foster Avenue building to address arsenic that is a source to groundwater.

- An excavation ranging from four to six feet would be conducted north of the 10 Foster Avenue building and west of the Silver Lake conveyance system to address the PCBs at concentrations greater than 50 mg/kg.

- An excavation of up to four feet would be performed beneath the building slab of the former 6 E Clementon Road building and the parking area west of the 2 and 4 Foster Avenue buildings. The excavation would extend to the shallower of four feet or where the RDCSRS are achieved.

- An excavation of up to four feet would be performed beneath the parking area of the 7 Foster Avenue building. The excavation would extend to the shallower of four feet or where the RDCSRS are achieved.

Following the excavations, the areas would be backfilled to grade, and an impermeable cap would be installed.

Implementation of the soil removal component in this alternative would involve the following major steps:

- Survey of property boundaries;

- A supplemental pre-design investigation;

- Establishment of laydown areas and erosion and sedimentation (E&S) Controls;

- Establishment of exclusion areas for public safety;

- Construction mobilization;

- Obtaining utility clearances and, as needed, implementing measures for utility protection;

- Closure of monitoring wells within the excavation areas;
- Installation of temporary access roads;
- Establishment of perimeter air monitoring for dust;
- Removal of asphalt parking area and a portion of the 6 East Clementon Road building slab;
- Excavation of contaminated soil;
- Management of groundwater;
- Dewatering and/or stabilization of wet soil;
- Soil waste classification;
- Transportation and disposal (T&D) at an approved disposal facility;
- Backfill of the excavation with clean soil;
- Site restoration;
- Long-term maintenance of the engineering controls; and
- Establishment of a Deed Notice.

Former Resin Plant/Tank Farm A Area

Based on these considerations, the remedial activities to be conducted in the Former Resin Plant/Tank Farm A area would be the same as those discussed for Soil Alternative 3:

1. Maintenance of the current impermeable cap and soil cover.

2. Evaluation of the arsenic found at a concentration greater than the IGWSRS beneath the soil cover to determine whether it can be left in place or needs to be removed.

3. Installation of a LNAPL recovery system targeting locations where some recoverable LNAPL may still be present.

4. Installation of a series of injection wells to deliver nutrients to stimulate the biodegradation of the LNAPL in the subsurface.

5. Installation of a system to remove the methane and other vapors from the subsurface beneath the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings.

The LNAPL recovery system would be installed beneath the 2 Foster Avenue building, the location where LNAPL is most likely to be recoverable. For purposes of this FS, the recovery system would consist of:

- Eight new 4-inch LNAPL extraction wells. Based on the understanding of the depth at which the LNAPL is encountered and the thickness of the LNAPL, the recovery wells would be installed to an approximate depth of 15 feet.

- Four in-well electrically-powered LNAPL skimmers (to alternate between wells), complete with:

    - Autoseeker spool (wellhead mount)

    - Control box

    - Down-well robe (with pump and level sensor)

- Cables and product discharge tubing
- Tank full shut-off control

- Product recovery tank with spill/leak containment
- Electrical connections
- Security fencing

Figures showing the details of the recovery system as well as detailed assumptions used to develop cost estimates are provided in Appendix E of the FMP FS.

Operation and maintenance is assumed to include:

- Monitoring of skimmer pump operations, product levels in tanks, removal of accumulated product, and gauging of wells on a monthly basis;
- Quarterly rotation of skimmers between wells;
- Quarterly off-site transportation and disposal of the LNAPL; and
- Replacement of one LNAPL pump assembly every six months, and replacement of one LNAPL skimming assembly every year.

For cost purposes, it is assumed that the recovery system would operate for a period of three (3) years.

A system to enhance the existing biological processes that are degrading the LNAPL would be installed throughout the Former Resin Plant/Tank Farm A area. The system would inject fertilizer-like ingredients such as sulfate, nitrogen and phosphorous. These ingredients would be delivered by a system consisting of:

1) A network of shallow 15-foot deep PVC fertilization wells, designed to stimulate the biodegradation that is occurring, spaced across the treatment area.

2) A series of trenches in which irrigation piping and emitters are installed.

In addition, because methane is generated as part of the biodegradation of the LNAPL, and other petroleum vapors are generated by volatilization of the LNAPL components, a soil ventilation system that would prevent indoor exposure to these constituents would be part of the system design.

The conceptual system design of the bioremediation system is based on the assumption of a treatment rate of one pore volume (approximately 5,000,000 gallons) per year over a treatment zone of 700' x 350' x 10' (2,450,000 ft^3), a porosity of 0.27, which would result in a continuous application rate of approximately 9.5 gpm.

The system would consist of:

- Preparation and submission of permit applications to NJDEP for chemical injection.

- A network of 2-inch diameter, 15-foot deep PVC bioremediation wells at nominal 40-foot centers outside the buildings and high-pressure injection wells on 80-foot centers within the buildings. Wells installed north of Foster Avenue will deliver nutrients beneath Foster Avenue to stimulate biodegradation of LNAPL that is present beneath the roadway.

- Installation of pipe trenches throughout the 2 and 4 Foster Avenue parking area to a depth of approximately four feet. The pipe trenches would carry conveyance pipes to deliver the nutrients to each injection well and drip irrigation piping that would deliver the nutrients from near surface to the top of the water table. The drip irrigation pipe would be equipped with 4-gallons per hour (gph) emitters at 1-foot centers in the buried pipe trenches.

- Installation of horizontal nutrient delivery wells beneath the 2 and 4 Foster Avenue buildings.

- Installation of vertical soil gas extraction/subsurface ventilation wells within the 2 and 4 Foster Avenue parking area, and horizontal soil gas extraction/ soil ventilation wells beneath the 2 and 4 Foster Avenue building. Note that the conceptual design is for FS costing purposes only. The actual number and layout of the soil gas extraction/ventilation wells would be determined based on pilot testing.

- A 1,000 ft^2 heated equipment building/enclosure and fenced compound for housing of nutrient storage, mixing, and delivery equipment, and soil gas extraction equipment.

- A soil gas extraction blower.

- A 115/230-volt electrical service (100-amp minimum) to the treatment building.

- Nutrient mixing and pumping assembly.

- A PLC and nutrient injection controller system for automated delivery of water and reagents to the bioremediation wells and drip irrigation systems.

- Soil gas monitoring probes installed along United States Avenue and north of the 4 Foster Avenue/3 U.S. Avenue building.

- Utilities, consisting of:

    - A municipal water service capable of providing 20 gpm supply.

- Internet service to support the PLC and enable automated monitoring and control of equipment.

Operation and maintenance of this system would consist of:

- Weekly system inspections and automated monitoring of system functions, including water flow rates and injected pressures, volumes injected into individual wells and nutrient delivery lines, and amounts of nutrients used and available.

- Weekly maintenance on the extraction blower, and field measurement of vapor concentrations with organic vapor analyzer (for VOCs) and landfill gas monitor (for methane and CO_2).

- Soil gas monitoring in soil gas probes to assess concentrations of VOCs, methane and carbon dioxide to determine the presence of biological activity and effectiveness of soil gas extraction systems. Soil gas monitoring would be conducted monthly for the first year, quarterly for the next 2 years, semiannually for the next 2 years, and annually thereafter for 5 years.

- Quarterly monitoring of shallow groundwater for two years, and semi-annual monitoring after the first two years.

It has been estimated that the system would need to operate for a period of seven years, but for cost purposes an operating period of 10 years has been used.

Implementation of the LNAPL extraction and nutrient injection alternative would involve the following major steps:

- Pilot tests to evaluate the presence of recoverable LNAPL and radii of influence for nutrient injection and soil gas ventilation wells;

- Permitting for nutrient injection and building construction;
- Establishment of laydown areas and erosion and sedimentation (E&S) Controls;
- Establishment of exclusion areas for public safety;
- Construction mobilization;
- Obtaining utility clearances and, as needed, implementing measures for utility protection;
- Protection of monitoring wells within the nutrient injection areas;
- Establishment of perimeter air monitoring for dust;
- Excavation of soil for piping trenches;
- Installation of nutrient injection wells, LNAPL recovery wells, and soil gas extraction wells;
- Backfilling of piping trenches to restore the impermeable cap and soil cover;
- Off-site transportation and disposal of excess soil from piping trench excavation;
- Installation of LNAPL recovery system;
- Building construction;
- Installation of nutrient mixing and delivery system;
- Installation of soil gas extraction blower;

- Utility connections;
- Operation and maintenance of the LNAPL recovery, nutrient injection and soil gas ventilation systems;
- System decommissioning;
- Establishment of a Deed Notice.

Seep Area

The component of Soil Alternative 3A applicable to the Seep Area is the same as Soil Alternative 3, removal of the accessible LNAPL. This would include removal of approximately five to seven feet of soil from the 1 and 5 Foster Avenue parking area, and approximately seven to ten feet of soil from the slope areas between the parking area and Foster Avenue to the north and U.S. Avenue to the east. The 5 Foster Avenue building would not be removed, so LNAPL may remain under it, and LNAPL would remain beneath U.S. Avenue south of Foster Avenue. It is expected that, by removing the vast majority of the LNAPL from the Seep Area, the relatively small mass of LNAPL that may be present beneath the 5 Foster Avenue building would biodegrade. However, until such time as this occurs, a Deed Notice would be required for the 5 Foster Avenue building. Nutrient injections to stimulate biodegradation of the LNAPL beneath U.S. Avenue are a component of a remedial alternative for the Eastern Off-Property Area (see FMP FS).

Alternative 3A would also include a LNAPL recovery trench south of Foster Avenue. The purpose of the trench is to capture any LNAPL that may be mobilized during the LNAPL soil removal activities in the Seep Area as well as any LNAPL that may potentially be mobilized as a result of the nutrient injection in the former Resin Plant/Tank Farm A Area. Therefore, any potential for LNAPL transport towards the Seep Area and Hilliards Creek would be eliminated.

The trench would be approximately 400 feet long, seven feet deep and three feet wide. It would extend along U.S. Avenue for approximately 100 feet to the corner of U.S. Avenue and Foster Avenue and then approximately 300 feet to the interpreted western end of the LNAPL. Sumps would be installed at approximately 100-foot distances along the trench, and skimmer pumps would be installed. Any recovered LNAPL would be transferred to dedicated and secure totes before off-site transport for disposal. It is assumed that the skimmers would operate for three years. A detailed discussion of the assumptions used in developing costs for the recovery trench were presented in Appendix E of the FMP FS.

Implementation of this alternative would involve the following major steps:

- Survey of property boundaries;
- Delineation of Upper Hilliards Creek wetlands transition zone and flood hazard area;
- Performing a supplemental pre-design investigation, including sampling beneath the 1 Foster Avenue building;
- Obtaining permit equivalencies for wetlands transition area and flood hazard area, if required;
- Establishment of laydown areas and erosion and sedimentation (E&S) Controls;
- Establishment of exclusion areas for public safety;
- Construction mobilization;
- Obtaining utility clearances and, as needed, implementing measures for utility protection;
- Closure of monitoring wells within the excavation areas;

- Installation of temporary access roads;
- Establishment of perimeter air monitoring for dust and vapors;
- Excavation of contaminated soil;
- Management of groundwater;
- Dewatering and/or stabilization of wet soil;
- Waste classification sampling;
- Transportation and disposal (T&D) of contaminated soil and waste at an approved disposal facility;
- Backfilling the excavation with clean soil;
- Installation of the LNAPL recovery trench;
- Site restoration, including reinstallation of the impermeable asphalt parking area;
- O&M of recovery trench;
- Long-term maintenance of the engineering controls; and
- Establishment of a Deed Notice.

It is anticipated that this component of Alternative 3A would require approximately 18 months to complete. As part of the implementation, approximately 36,000 CY of soil would be removed from the Site and disposed at a properly permitted facility.

Upper Hilliards Creek

Soil Alternative 3A for Upper Hilliards Creek is the same as Soil Alternative 3 and would consist of removing all soil from the Upper Hilliards Creek floodplain that, in the 0'–1' interval, contains constituents at concentrations greater than the PRGs, and, in intervals deeper than 1', contains constituents at concentrations greater than the RDCSRS. Since groundwater within the majority of the Hilliards Creek floodplain is at or near the surface, the IGWSRS do not generally apply.

Although NJDEP guidance states that the residential and nonresidential soil standards are generally not applicable to ecological habitat areas because human exposure frequencies in the ecological habitat areas are different than residential and nonresidential settings, Upper Hilliards Creek is easily accessible by the public and portions of the floodplain border residential properties.

The depths of excavation would range from approximately one to six feet. As part of the remedial action, temporary water diversion structures, such as portadams or sheet piling, would need to be installed along Upper Hilliards Creek, to prevent surface water discharges into the removal areas and contaminated soil from entering Hilliards Creek. Since the excavations would extend beneath the water table, groundwater management would be required. For purposes of this FS, it has been assumed that groundwater would be collected, filtered and disposed off site. If a permit equivalency for treatment and discharge to Hilliards Creek can be obtained, costs for this alternative may be slightly less than estimated.

Under this alternative, approximately 10,000 CY of soil would be removed from the Upper Hilliards Creek floodplain, and an equal amount of soil would be imported as backfill. As much as 1,000,000 gallons of groundwater produced as part of the remedial action may require off-site disposal. Slightly over two acres of wetlands and wetlands transition areas would need to be restored.

Former Lagoon Area

The component of Soil Alternative 3A applicable to the former Lagoon Area is the same as Soil Alternative 3 and would consist of:

- Conducting a PDI to evaluate possible sources of VOC/SVOC TICs in groundwater and determine if a source area for pentachlorophenol is present in the eastern portion of the area.

- Conducting focused removal of surface soils to address pentachlorophenol and PAHs where present at concentrations greater than the RDCSRS.

- Developing a site-specific IGWSRS to support evaluation of the need to remove soil in the unsaturated zone where pentachlorophenol is present at concentrations greater than the IGWSRS (0.3 mg/kg).

- Removal of soil to a depth of approximately six to eight feet in the northwest corner of the Former Lagoon Area which may be a source of pentachlorophenol to groundwater.

- Conducting any additional removal that may be required to address sources of pentachlorophenol to groundwater based on the results of the PDI.

Based on the current understanding of the distribution of constituents in soil, approximately 4,000 CY of soil would be removed as part of this alternative, and an equal amount of soil would be imported for use as backfill. Since the excavation would extend only approximately six to eight feet, groundwater management is not anticipated to be a significant concern.

Alternative 3A Summary

Based on the current understanding of the distribution of constituents in soil and the extent of the LNAPL, Soil Alternative 3A would consist of:

- Removal and off-site disposal of approximately 35,500 CY of soil from the Main Plant Area to address sources of arsenic in groundwater, PCBs at concentrations greater than 50 mg/kg, and soil at concentrations greater than the RDCSRS to a depth of four feet;

- Removal of any underground structures that may be sources of contamination;

- LNAPL recovery, biostimulation and soil gas ventilation in the Former Resin plant/Tank Farm A area;

- Installation of a LNAPL recovery trench south of Foster Avenue to prevent transport of LNAPL from the Former Resin Plant/Tank Farm A area towards the Seep Area and Hilliards Creek;

- Removal of approximately 15,000 CY of soil from the Seep Area to address LNAPL;

- Removal of approximately 10,000 CY of soil from the Upper Hilliards Creek floodplain to address constituents present in surface soil at concentrations greater than the PRGs and constituents in subsurface soil at concentrations greater than the RDCSRS;

- Restoration of the Upper Hilliards Creek floodplain;

- Removal of approximately 4,000 CY of soil from the Former Lagoon Area to address constituents present in the upper two feet at concentrations greater than the RDCSRS and sources of pentachlorophenol in groundwater;

- Installation of a groundwater monitoring network in those areas where groundwater monitoring wells were removed during the remedial action (the monitoring well network will be used to monitor the effectiveness of the remedial action such that modifications can be made, as necessary, to ensure the remedial action does not cause an increase in the extent of dissolved-phase constituents at concentrations greater than the GWQS); and

- Deed Notices for those parcels where constituents remain at concentrations greater than the RDCSRS.

Total costs for Soil Alternative 3A are estimated to be $31 million. It is estimated that approximately two and a half years would be required to complete the remedial construction, with 18 months required for the Main Plant excavation.

4.0 COMPARATIVE ANALYSIS OF FMP SOIL ALTERNATIVES

Pursuant to EPA guidance for preparation of FSs, the identified remedial alternatives were evaluated based on seven criteria discussed in Section 2 of this FS Addendum. Figure 4 provides a summary of the results of the analysis.

The following provides the comparative analysis of the five soil alternatives against the two Threshold Criteria and the five Balancing Criteria.

4.1. Overall Protection of Human Health and the Environment

Soil Alternative 1 - No Action would not provide protection of human health and the environment. Although a cap is present over the majority of the site, preventing direct contact with the constituents in soil, the human health and ecological exposures along Hilliards Creek and the former Lagoon Area would remain, and no action would be conducted to address sources of groundwater contamination or the LNAPL. This alternative would not achieve the RAOs for the Site. Institutional controls would not be established to prevent exposure to contaminated soil or provide guidance in the event that exposure occurs. Routine monitoring of site conditions would not be conducted and future changes in contaminant conditions would not be identified.

Soil Alternative 2 – Targeted Surface Soil Removal, Capping and Institutional Controls would be protective of human health and ecological receptors. All exposure pathways would be eliminated by soil removal (in the ecological habitat areas), existing and new capping (in other areas of the Site), and institutional controls (a Deed Notice). The soil removal and capping in the ecological habitat areas would prevent transport of soil containing contaminants into surface water bodies. However, under this alternative, sources of groundwater contamination would remain, no actions to remove or contain the LNAPL would be performed, and no actions would be conducted to mitigate the soil gas vapors beneath the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings. Therefore, there would remain the possibility that, without ongoing manual recovery activities, discharges of LNAPL to Hilliards Creek and indoor exposure to vapors originating in the subsurface could occur.

Soil Alternative 3 - Soil and LNAPL Treatment/Removal, Capping and Institutional Controls would be protective of human health and ecological receptors. The combination of soil and LNAPL removal, and use of existing structures for capping, would eliminate all exposure pathways. Within ecological habitat areas, all surface soil within the ecological habitat areas would meet PRGs. Where subsurface soil does not meet the RDCSRS within the former Lagoon Area, a cap would be installed. The soil removal and capping in the ecological habitat areas would prevent transport of soil containing contaminants into surface water bodies.

Alternative 3 would remove sources of arsenic in groundwater at the Main Plant Area and sources of pentachlorophenol and, based on the results of the PDI, potentially the VOC and SVOC TICs in the Former Lagoon Area. Alternative 3 would also remove the accessible LNAPL from the Seep Area, enhance LNAPL degradation in the Former Resin Plant/Tank Farm A area and implement LNAPL recovery actions beneath the 4 Foster Avenue building and south of Foster Avenue. The biostimulation in the former Resin Plant/Tank Farm A Area would enhance biodegradation beneath Foster Avenue and the upper portion of U.S. Avenue. The LNAPL removal in the Seep Area would remove the vast majority of LNAPL, such that any remaining LNAPL beneath the 5 Foster Avenue building would biodegrade. Treatment of the LNAPL beneath the southern portion of U.S. Avenue is contemplated in a remedial alternative for the Eastern Off-Property Area.

The subsurface soil ventilation system would remove/biodegrade the methane and petroleum vapors from beneath the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings, and the associated parking areas. A Deed Notice would be established to prevent unauthorized activities in areas where constituents remain in soil at concentrations greater than the RDCSRS.

Soil Alternative 3A - Soil and LNAPL Treatment/Removal, Capping with Supplemental Excavation, and Institutional Controls – would be protective of public health and the environment. All of the benefits of Soil Alternative 3 would be obtained. The additional soil removal beneath the parking areas west of 2 and 4 Foster Avenue and surrounding the 7 Foster Avenue building would provide up to four feet of additional separation between constituents in soil in these areas and any receptors.

Soil Alternative 4 – Extensive Excavation to Depth, Capping and Institutional Controls would be protective of human health and ecological receptors. All surface soil containing constituents at concentrations greater than the PRGs in ecological habitat areas would be removed. All accessible subsurface soil containing constituents at concentrations greater than the RDCSRS would be removed, and, where the soil is not accessible (such as beneath Foster Avenue, U.S. Avenue and the remaining buildings), the direct contact pathway would be eliminated. Achieving the PRGs in the ecological habitat areas would also prevent transport of constituents into the water bodies. By removing all accessible subsurface soil containing constituents at concentrations greater than the RDCSRS, the sources of groundwater contamination would be addressed. A Deed Notice would be established for the areas of the property where soil remains at concentrations greater than the RDCSRS to prevent unauthorized contact.

4.2. Compliance with ARARs

Soil Alternative 1 - No Action would not meet chemical-specific ARARs for those areas where soil containing constituents at concentrations greater than the NRDCSRS is present and not capped, where soil at concentrations greater than the RDCSRS and no Deed Notice is established, and those ecological habitats where constituents remain in surface soil at concentrations greater than the PRGs. Control of groundwater contamination sources would not be achieved. No efforts to recover or contain LNAPL would be performed and soil gas vapors would remain beneath the 2 and 4 Foster Avenue buildings. Since no site activity (i.e., construction) would be required, location-specific and action-specific ARARs do not apply to this alternative.

Soil Alternative 2 – Targeted Surface Soil Removal, Capping and Institutional Controls would not achieve ARARs for control of groundwater sources, removal or containment of LNAPL, or management of PCBs. However, surface soil containing constituents at concentrations greater than the PRGs would be removed from the Upper Hilliards Creek floodplain, and a cap would be placed over areas where constituents remain in subsurface soil at concentrations greater than the RDCSRS. In other areas of the Site, the existing buildings and other impermeable surfaces would provide a cap, and a Deed Notice would be established for all parcels where constituents remain at concentrations greater than the RDCSRS. Because all surface soil containing constituents at concentrations greater than PRGs would be capped, the potential for surface water standard exceedances due to contaminated storm water runoff would be eliminated.

Soil Alternatives 3, 3A and 4 would achieve all ARARs. All surface soil containing constituents at concentrations greater than the PRGs would be removed from ecological habitat areas in the Upper Hilliards Creek floodplain and the former Lagoon Area. All alternatives would:

- address any locations where either default or site-specific exceedances of the IGWSRS are found;
- remove sources of groundwater contamination and PCBs above 50 mg/kg,
- remove or contain LNAPL to the extent practicable;

- remove the soil vapors from beneath the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings, and

- cap all soil left in place at concentrations greater than the RDCSRS and establish a Deed Notice would be established for all areas where constituents remain in soil at concentrations greater than the RDCSRS.

4.3. Long-Term Effectiveness and Permanence

Soil Alternative 1 - No Action does not provide long-term effectiveness and permanence for those areas where soil containing contaminants at concentrations greater than ARARs is present. Existing contamination, exposures and risks would remain.

Soil Alternative 2 – Targeted Surface Soil Removal, Capping and Institutional Controls would provide long-term effectiveness and permanence for control of direct contact exposure by human health and ecological receptors to constituents in soil. It can be expected that the cap placed on the Site would be maintained as required by regulation, eliminating direct contact with Site-related constituents to human and ecological receptors. Similarly, because the cap would be maintained, the potential for surface water exceedances as a result of contaminated storm water runoff would be eliminated. The institutional controls would notify future owners, occupants and workers of the presence of constituents in soil (Deed Notice) to prevent unauthorized intrusive work on the Site. However, the sources of groundwater contamination would remain, such that the long-term effectiveness and permanence of the remedy for groundwater would be dependent upon the chosen groundwater remedy.

Soil Alternative 3 – Soil and LNAPL Removal/Treatment, Capping and Institutional Controls would provide a high degree of long term effectiveness and permanence because all surface soil containing constituents greater than the PRGs and subsurface soil containing constituents at concentrations greater than the RDCSRS would be removed from the Upper Hilliards Creek floodplain, the sources of groundwater contamination would be removed from the Former Main Plant and Lagoon areas, the LNAPL would be removed to the extent practicable and the degradation processes would be enhanced, and the methane and petroleum vapors produced by the degradation of the LNAPL would be removed.

Removing surface soil containing constituents at concentrations greater than the PRGs would eliminate the potential for exceedances of surface standards due to contaminated storm water runoff. The removal of the sources of groundwater contamination provides permanence for the groundwater remedy because there would not be a need to rely on active groundwater treatment to achieve the GWQS. Removing the LNAPL south of Foster Avenue and installing a recovery trench would eliminate the potential for discharges to Hilliards Creek. Removing and enhancing degradation of LNAPL north of Foster Avenue would reduce the time frame that the LNAPL acts as a source to groundwater and soil gas vapors.

Soil Alternative 3A - Soil and LNAPL Removal/Treatment, Capping with Supplemental Excavation, and Institutional Controls would provide a somewhat greater degree of long-term effectiveness and permanence than Soil Alternative 3. In addition to all of the actions included in Soil Alternative 3, Soil Alternative 3A would remove up to four feet of soil beneath the caps that consist of the parking area west of the 2 and 4 Foster Avenue buildings and the parking area surrounding the 7 Foster Avenue building. The additional excavation would provide additional separation between any constituents that may remain in soil at concentrations greater than the RDCSRS and any potential receptors. It would also minimize the need to rely upon the integrity of the asphalt cap as the sole barrier between any receptor and constituents that may remain in soil at concentrations greater than the RDCSRS.

Soil Alternative 4 – Extensive Excavation to Depth and Institutional Controls provides an equivalent degree of long-term effectiveness and permanence as Soil Alternative 3A. As with Soil Alternative 3A, all surface soil containing constituents greater than the PRGs and subsurface soil containing constituents greater than the RDCSRS would be removed from the Hilliards Creek floodplain. Under Alternative 4, all subsurface soil containing constituents at concentrations greater than the RDCSRS would be removed from the remainder of the Site except for inaccessible areas beneath roadways and some buildings. The additional removal would not appreciably increase the degree of long-term effectiveness and permanence offered by Alternative 3A because, under Alternative 3A, receptors would be separated from any constituents remaining in soil at concentrations greater than the RDCSRS by clean soil of approximately four feet or more (Main Plant, former Lagoon Area), or would be addressed by treatment (former Resin Plant/Tank Farm A Area).

Sources of groundwater contamination and LNAPL would also be removed. Removing surface soil containing constituents at concentrations greater than the PRGs from the ecological habitat areas would eliminate the potential for exceedances of surface standards due to contaminated storm water runoff. The removal of the sources of groundwater contamination and LNAPL would provide permanence for the groundwater remedy because there would not be a need to rely on active groundwater treatment to achieve the GWQS.

4.4. Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility or volume through treatment would occur for the LNAPL under Alternatives 1, 2, 3 and 3A since, as documented in the "LNAPL Investigation Report, Former Manufacturing Plant Area, Gibbsboro, New Jersey" (Final LNAPL Report, EHS 2018), there would be ongoing biodegradation of the LNAPL. Under Alternatives 1 and 2, reduction in toxicity, mobility or volume through treatment would occur at the same rate as current conditions. Soil Alternatives 3 and 3A, which would stimulate the LNAPL degradation through enhancing the ongoing bioremediation, would provide the highest degree of reduction of toxicity, mobility or volume through treatment. Soil Alternative 4 does not provide for reduction of toxicity, mobility or volume through treatment because soil removal, not treatment, would be the approach used for remediation.

4.5. Short-Term Effectiveness

All of the soil alternatives where excavation is involved would have some degree of short-term impacts upon the community and the environment. Based on the projected schedules for each alternative, short term impacts would range from several months to almost five years. The impacts include vehicular (truck and heavy construction equipment) traffic, noise, emissions, possible road closures, potential damage to roadways, and short-term ecological habitat destruction. These short-term impacts are unavoidable, and the extent of the impacts is a function of the extent of the remedial action. That is, the more extensive the remedial action is, more soil is removed, and larger areas are impacted. Accordingly, the remedial action requires a longer period of time to complete, and results in a greater number of truckloads of soil and backfill, having a higher degree of short-term impact.

The short-term impacts of Soil Alternatives 3, 3A and 4 - those alternatives in which large volumes of soil would be removed – would be substantial. Under each of these alternatives, large volumes of soil would be removed and brought onto the Site as backfill or cap material. Also, large portions of the Site would be affected or encumbered during the remedial action.

Under Alternative 3, almost 40,000 CY (nearly 70,000 tons) of soil would be removed as part of the remedial action for the Main Plant, Hilliards Creek, Seep Area and former Lagoon Area. A similar volume of soil would be brought onto the site for backfilling and capping. Using a typical truck load of 20 tons, these numbers translate to approximately 7,000 truck trips to move 70,000 tons of soil into and another 70,000 tons of soil out of the Site. These trucks would use U.S. Avenue, Clementon Road, Foster Avenue and other two-lane surface streets to get to and from the Site.

Alternative 3A would add approximately 27,000 CY (38,000 tons) of soil removal for a total of approximately 108,000 tons. Based on 20 tons of soil per truck, a total of almost 11,000 truck trips would be needed to remove 108,000 tons of contaminated soil from the site and bring 108,000 tons of clean soil onto the site. The additional soil removal that would be conducted under Alternative 3A would be in the Main Plant Area, so all of the additional trucks (approximately 3,800 loads) would use Foster Avenue to access either U.S. Avenue or Clementon Road.

Under Soil Alternative 4, more than 300,000 CY (more than 450,000 tons) of soil would be removed from, and brought onto, the Site. This translates to more than 45,000 truck trips solely to move soil to and from the Site under this alternative. This does not account for transport of concrete, asphalt and other debris generated during the soil removal or the construction debris generated by the building demolition.

Currently, access to the Site is from U.S. Avenue and West Clementon Road. Depending upon the volume of truck traffic entering and leaving the Site during construction, there may be a need for intermittent closures of one or both of these streets. Residences are present on both U.S. Avenue and Clementon Road, and the trucks would be routed past these properties. It can be expected that there would be closures of Foster Avenue. Traffic control would be required for U.S. Avenue and West Clementon Road while trucks enter and leave the Site.

Under Soil Alternatives 3, 3A and 4, extensive excavation would be conducted in the parking area of the 5 Foster Avenue building, the current headquarters for the Gibbsboro Police Department. The excavation that would be conducted under these alternatives could potentially restrict access to the 5 Foster Avenue building or require relocation of the police department.

Alternatives 3A and 4 would have increased short-term impacts to the 7 Foster Avenue and 10 Foster Avenue building structures and occupants in comparison to Alternative 3. Under Alternatives 3A and 4, excavation would be conducted around both buildings to depths of four feet or greater. Therefore, there is a potential for structural damage to buildings, there will be noise issues associated with activities such as sheet pile installation and excavation, and there are potential safety issues associated with building occupants accessing the buildings during remedial action. The additional trucks that will be required for Alternatives 3A and 4 also pose additional safety hazards to building occupants.

Under Alternatives 3, 3A and 4, remediation would be conducted on approximately three acres of regulated wetlands and transition areas in the Upper Hilliards Creek floodplain and the former Lagoon Area. The majority of the Site is currently wooded, containing large overstory trees. Under any of the remedial alternatives, the entire three acres would be cleared, including the land immediately behind residential properties B-4 through B-7. Although the Site would be restored, it would be years or decades before this portion of the Site would return to its current status.

Based on the understanding of the activities that would be conducted under each alternative, the comparison of short-term effectiveness follows.

- Soil Alternative 1 would have no short-term impacts because there is no construction activity associated with either alternative.

- Soil Alternative 2 - Targeted Surface Soil Removal, Capping and Institutional Controls would have the least short-term impacts than any of the alternatives in which soil removal would be conducted. The volume of soil that would be removed is significant (approximately 8,000 CY), and approximately 3 acres of forested floodplain would be cleared as part of the remedial action. The construction time frame would be the least of all of the soil removal alternatives but would still extend for approximately 9 months.

- The short-term impacts associated with Soil Alternative 3 would be greater than those for Soil Alternative 2. Approximately 40,000 CY of soil would be excavated, and an equivalent volume of soil would be imported onto the Site. This translates to approximately 7,000 truck trips to move soil to and from the Site. As discussed previously, there are no alternatives to U.S. Avenue and West Clementon Road by which to access the Site. As with Soil Alternative 2, the entire Hilliards Creek floodplain would be cleared as part of the remedial action. Soil Alternative 3 is expected to require approximately 16 months to complete.

- The short-term impacts for Soil Alternative 3A would be greater than those for Soil Alternative 3. An additional 38,000 tons of soil would be removed (a total of 108,000 tons), translating to another 3,800 truck trips to remove contaminated soil and import clean soil, and all of these trucks would use Foster Avenue to access Clementon Road and U.S. Avenue, roads with residential properties on them. The additional excavation surrounding the 7 Foster Avenue and 10 Foster Avenue buildings will create the potential for structural damage to the buildings and may prevent access to the buildings while construction is occurring. If access to the buildings is not prevented, the occupants will be subject to construction noise, truck traffic and other construction - related impacts. It is expected that this alternative will require approximately two and a half years to complete, with 14 months dedicated to the Main Plant Area.

- Soil Alternative 4 would pose very substantial short-term risks and impacts. Not only does it involve the removal of more than 300,000 CY (almost eight times as much soil as Alternative 3 and four times as much soil as Alternative 3A), the depths are much greater, and it would require the removal of two very large structures and the management of large volumes of produced groundwater and LNAPL mixture.

  Since the majority of soil excavated under Soil Alternative 4 would be from under the water table, a very large amount of soil would require stabilization to eliminate free liquids prior to off-site transport. For purposes of the FS, it is assumed that the stabilization would occur on the Site. If, however, construction of a separate facility to manage the soil is needed, additional time and truck trips would be required, which would increase the short-term impacts on the community. The likelihood of needing a separate facility is higher for this alternative due to the large volumes of soil that would need to be managed.

It is projected that it would require as long as five years to complete this alternative, and more than 45,000 truck trips in and out of the site would occur over this time.

Short-term risks to construction workers would also be the greatest under Soil Alternative 4. The most soil would be removed, the most truck trips would occur, and building demolition would be conducted.

4.6. Implementability

Similar to the "Short-Term Effectiveness" discussion, Soil Remedial Alternatives 2, 3, 3A and 4 would all have implementability difficulties:

- Conducting large-scale construction activities along U.S. Avenue, West Clementon Road and Foster Avenue would require careful planning, coordination with local authorities, and constant attention to ensure worker and public safety.

- Excavation next to U.S. Avenue and Foster Avenue may require the use of structural supports to prevent damage and allow for safe excavation of soil. This is particularly true for Soil Alternative 4, where deep excavations adjacent to Foster Avenue and U.S. Avenue would require special measures to ensure worker safety and road stability.

- Excavation near buildings, as is contemplated for Alternatives 3, 3A and 4 will require actions to ensure that there is no structural damage to the buildings. It will also require coordination with the current building occupants to ensure safe access to the buildings or to move the occupants to other locations during construction.

- Produced groundwater from the Former Resin Plant/Tank Farm A and Seep Area would likely contain measurable concentrations of petroleum compounds, requiring treatment or containerization and off-site disposal.

- Odor control would be needed for soil excavated from the Seep Area, as it can be expected that the LNAPL in soil would have a strong petroleum odor, and residential properties are immediately across U.S. Avenue from the Seep Area.

- Management of LNAPL in water would be necessary, particularly during excavation of the Seep Area, where LNAPL-containing soil would be removed.

- Ingress and egress for trucks and equipment would need to be planned and coordinated.

- Excavation of saturated soil would require management of groundwater as well as processing of saturated soil to meet disposal site requirements.

- Excavation in and along Upper Hilliards Creek would require the use of stream diversion measures and sediment and soil erosion measures to prevent downstream transport of contaminated soil during construction.

- Ecological restoration would need to be carefully designed and monitored, to ensure the functionality of the habitat would be restored and invasive species would be managed.

Again, these implementability difficulties are unavoidable for any of the active soil remediation alternatives. The difference in the implementability difficulties between Soil Alternatives 2, 3, 3A and 4 is the extent of the soil removal. The greater the volume of soil removed, the greater the implementability difficulties would be. When excavation depths are greater, the implementability difficulties are greater. When excavations are conducted adjacent to buildings or roadways, the implementability difficulties are greater.

Soil Alternative 1 - No Action would have the lowest degree of implementability difficulties, because no construction activities would be conducted under this alternative.

Alternative 2 - Targeted Surface Soil Removal, Capping and Institutional Controls would have the fewest implementability difficulties of any of the alternatives in which soil removal would be conducted, but the implementability issues would be significant. Acceptance of a Deed Notice by the current property owners would be needed. Approximately 8,000 CY of soil would be removed, with most from the Hilliards Creek floodplain, where excavation is predicted to be most difficult as a result of access and shallow water table conditions. One component of the excavation would be the soil between the two channels at the southern end of Upper Hilliards Creek, where both groundwater and surface water management would be required.

Site restoration along Upper Hilliards Creek is a significant implementability issue. Currently, the floodplain is a forested wetland and transition area with few invasive species noted. However, any disturbed area would potentially be subject to the propagation of invasive species.

Soil Alternative 3 – Soil and LNAPL Removal/Treatment, Capping and Institutional Controls would have greater implementability difficulties than would Soil Alternative 2. Much more soil would be removed (approximately 40,000 CY), and the majority of the additional soil would be from saturated conditions (Upper Hilliards Creek floodplain, the Seep Area and deep excavations on the Former Main Plant Area), so more groundwater would need to be managed, and more saturated soil would need to be stabilized. The produced groundwater in the Seep Area is likely to contain measurable amounts of petroleum hydrocarbons, which would likely require treatment prior to discharge or containerization and off-site disposal, and LNAPL may be present at the water table.

The excavation in the Seep Area next to U.S. Avenue and Foster Avenue is likely to require some level of structural support to prevent damage to the roadways. Acceptance of a Deed Notice by the current property owners would be needed.

The excavations along the Hilliards Creek floodplain would be deeper than under Alternative 2, producing more groundwater and requiring additional measures to limit surface water intrusion into the excavations. In the northern portion of Upper Hilliards Creek, the excavation on the west side may require structural stability measures to prevent damage to the 7 Foster Avenue building. Like Alternative 2, restoration of Upper Hilliards Creek would be difficult as a result of the potential for propagation of invasive species.

Soil Alternative 3A - Soil and LNAPL Removal/Treatment, Capping with Supplemental Excavation, and Institutional Controls would have greater implementability difficulties than Alternative 3. The excavation around the 7 Foster Avenue and 10 Foster Avenue buildings will add approximately 27,000 CY (38,000 tons) of additional excavation (a total of 108,000 tons) and will require measures to ensure structural stability. The additional excavation will also require coordination with the current building occupants to ensure safe access to the buildings during construction, or the occupants may need to be moved during the construction time frame. Conducting an excavation immediately adjacent to Silver Lake will require evaluation to ensure that no structural damage to the dam occurs as a result of the soil removal.

Soil Alternative 4, Extensive Removal to Depth and Institutional Controls would have by far the greatest degree of implementability difficulties of any alternative. The most soil would be removed (more than 300,000 CY), and the excavation depths would be extensive (20 feet in the Former Lagoon Area and 25 feet in the Former Resin Plant/Tank Farm A area). Because of the depth to which the soil removal would be performed, groundwater management would be a major implementability issue. As with Soil Alternative 3, any groundwater produced from the Former Resin Plant/Tank Farm A and Seep Areas can be predicted to contain measurable amounts of petroleum hydrocarbons, such that treatment or off-site disposal would be required. If excavations could not be conducted in saturated conditions, or if pumping and on-site discharge pursuant to a NJDEP permit by rule could not be used, even more groundwater would need to be containerized and disposed off site. Also because of the depth of the excavation, structural supports would be required along the entire perimeter of the excavations in the Former Lagoon Area and the Former Resin Plant/Tank Farm A Area.

4.7. Cost

Soil Alternative 1, No Action is the least costly alternative, followed by Soil Alternative 2, Targeted Surface Soil Removal, Capping and Institutional Controls, which is the least costly of the alternatives involving soil removal ($6 million), Soil Alternative 3, Soil and LNAPL Removal/Treatment, Capping and Institutional Controls ($24 million), Soil and LNAPL Removal/Treatment, Capping with Supplemental Excavation, and Institutional Controls ($31 million), and Soil Alternative 4, Extensive Removal to Depth and Institutional Controls ($87 million). The cost estimates for each alternative are presented in Table 1 and Appendix B.

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FIGURES

TABLES

Table 1: Estimated Costs for Soil Remedial Alternatives

APPENDICES

Appendix A: Response to Comments and Errata Pages

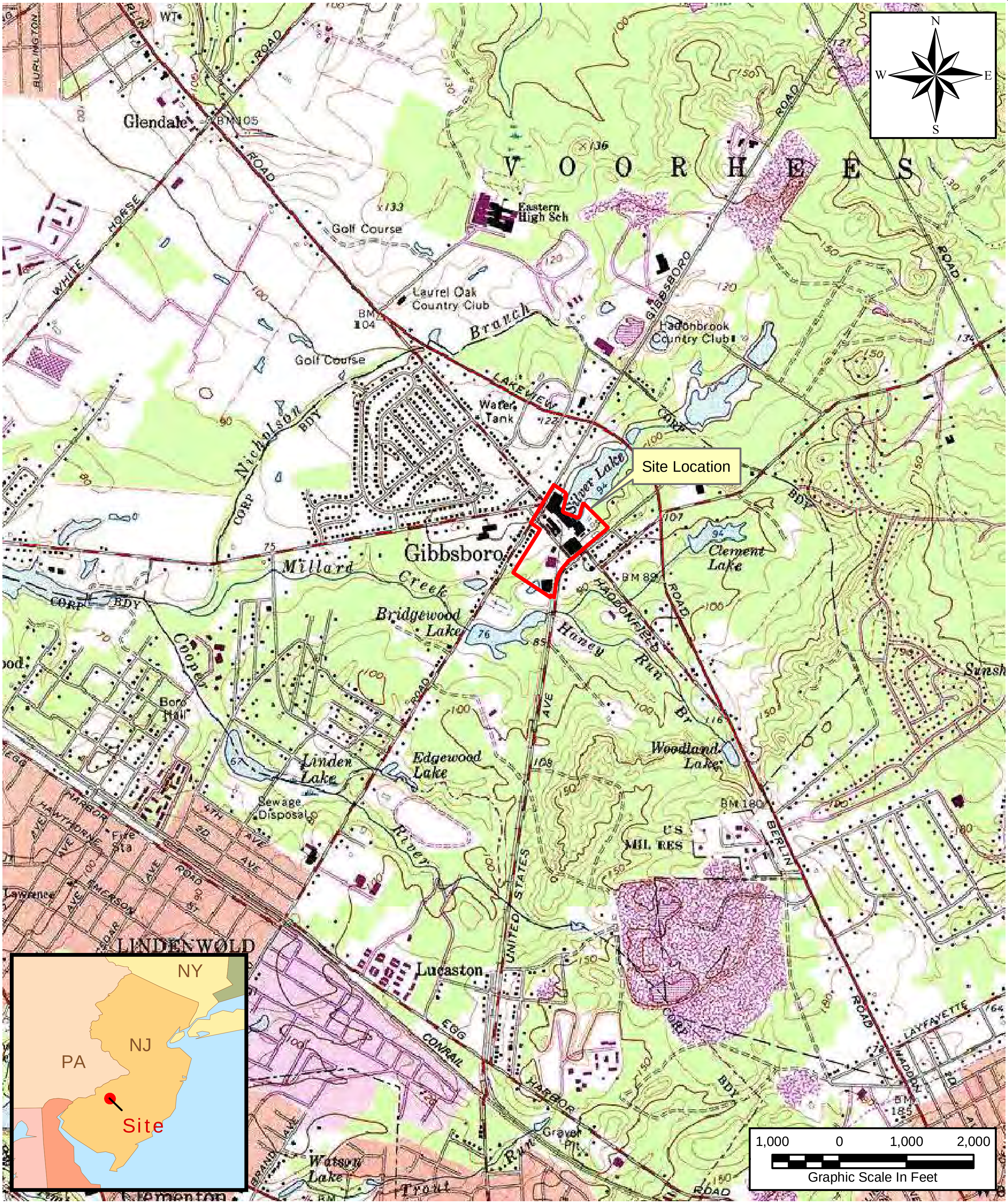
Appendix B: Cost Estimate, Soil Alternative 3A

APPENDIX A

Response to Comments and Errata Pages

APPENDIX B

Cost Estimates



LEGEND:

Former Manufacturing Plant Extent

SOURCE:

National Geographic TOPO! U.S. Geologic Survey (USGS). 7.5 Minute Series (Topographic) Quadrangles: Clementon, NJ, 1981.

PROJECT:

Former Manufacturing Plant
Feasibility Study

TITLE:

FORMER MANUFACTURING PLANT
SITE LOCATION MAP

CLIENT NAME:

The Sherwin-Williams Company

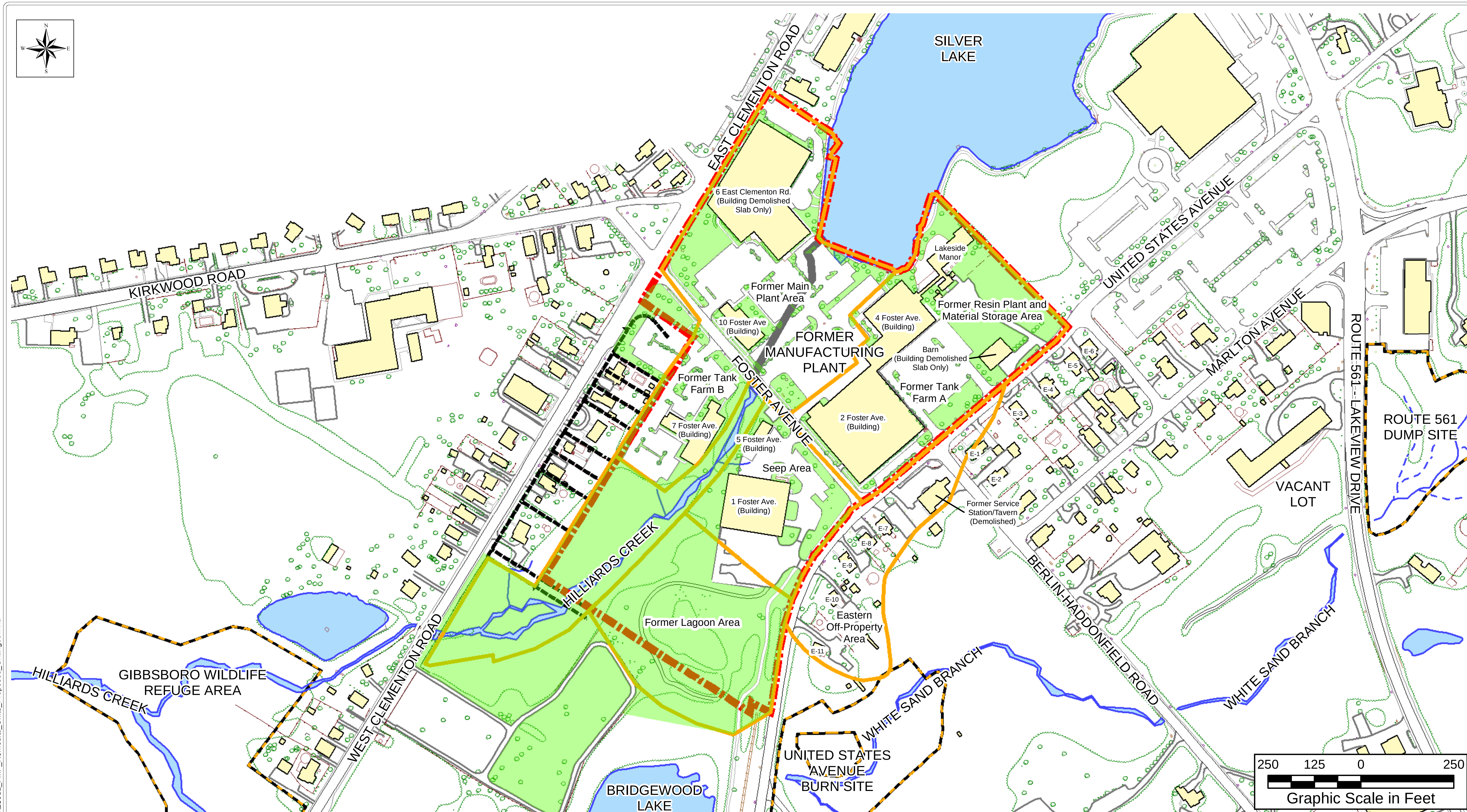
DATE:

May 2019

FIGURE #:

1

L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\23983_FMP_RIR_Topo.mxd

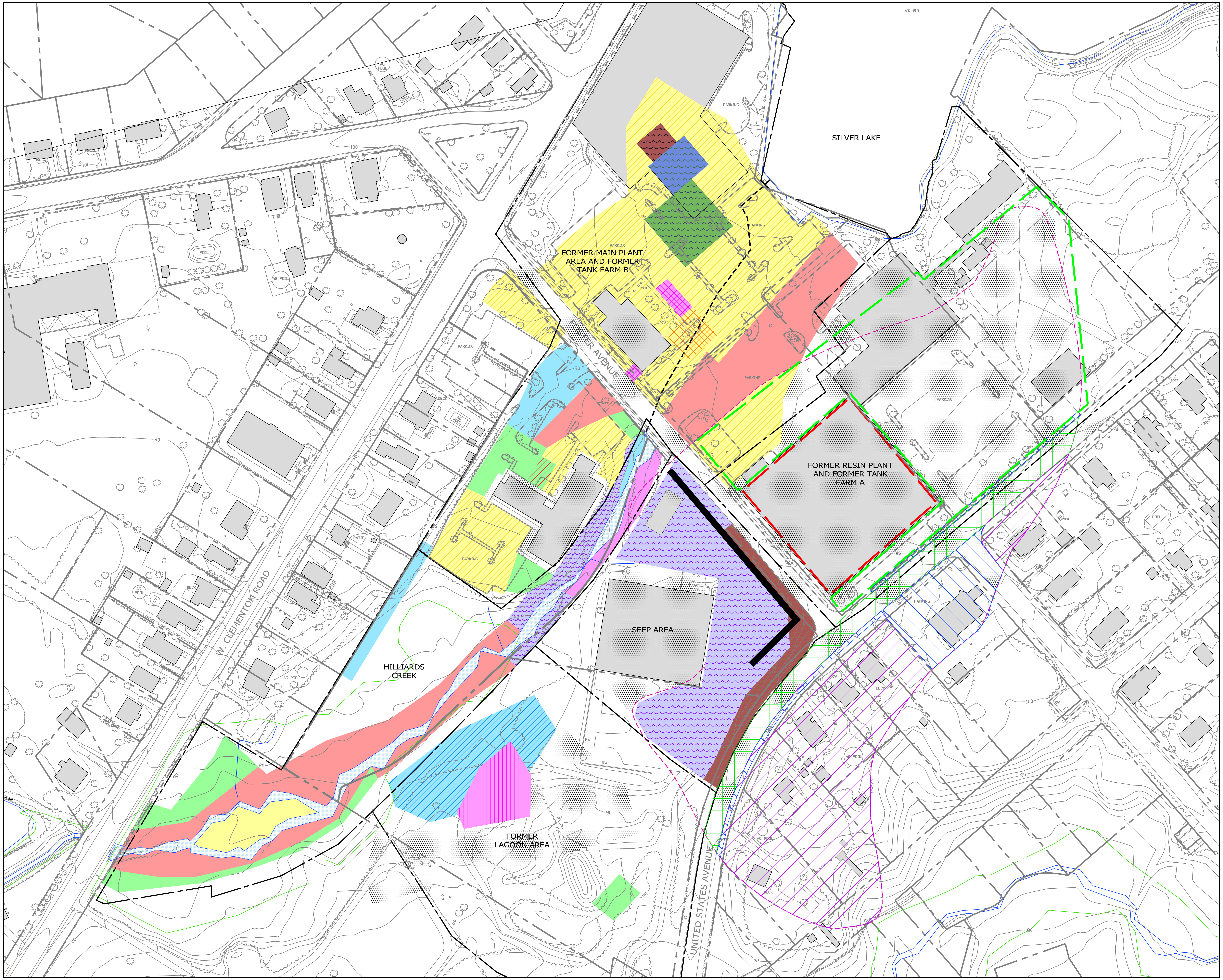


Legend

- Former Manufacturing Plant Remedial Units
- Former Manufacturing Plant Extent
- Unpaved Areas
- Surveyed Property Boundary (2015)
- Approximate Location of Silver Lake Conveyance

PROJECT NAME: Former Manufacturing Plant Feasibility Study	TITLE: FORMER MANUFACTURING PLANT REMEDIAL UNITS
CLIENT NAME: The Sherwin-Williams Company	
REPORT DATE: May 2019	DATE: 4/26/2019
	FIGURE #: 2

L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\23982_FMP_Remedial_Units_Proposed_Changes.mxd



LEGEND

- INTERPRETED EXTENT OF LNAPL
- PROPERTY LINE
- FORMER MANUFACTURING PLANT REMEDIAL UNITS
- 1-FOOT EXCAVATION FOR PRGs AND RDCSRS AND NO CAP
- 2-FOOT EXCAVATION FOR PRGs AND RDCSRS AND NO CAP
- 3-FOOT EXCAVATION FOR PRGs AND RDCSRS AND NO CAP
- 4-FOOT EXCAVATION FOR PRGS AND RDCSRS AND NO CAP
- 5-FOOT EXCAVATION FOR PRGs AND RDCSRS AND NO CAP
- 6-FOOT EXCAVATION FOR PRGS AND RDCSRS AND NO CAP
- 2-FOOT EXCAVATION FOR PRGs AND RDCSRS AND CAP FOR CONSTITUENTS GREATER THAN RDCSRS AT DEPTHS GREATER THAN 2 FEET
- 1-FOOT EXCAVATION FOR RDCSRS AND CAP FOR CONSTITUENTS GREATER THAN RDCSRS AT DEPTHS GREATER THAN 1 FEET
- 4-FOOT EXCAVATION FOR RDCSRS AND CAP FOR CONSTITUENTS GREATER THAN RDCSRS AT DEPTHS GREATER THAN 4 FEET
- 6-FOOT EXCAVATION FOR PRGS AND RDCSRS AND CAP FOR CONSTITUENTS GREATER THAN RDCSRS AT DEPTHS GREATER THAN 6 FEET
- 4-FOOT EXCAVATION FOR TSCA COMPLIANCE AND CAP FOR CONSTITUENTS GREATER THAN RDCSRS AT DEPTHS GREATER THAN 4 FEET
- 6-FOOT EXCAVATION FOR TSCA COMPLIANCE AND CAP FOR CONSTITUENTS GREATER THAN RDCSRS AT DEPTHS GREATER THAN 6 FEET
- 5-FOOT EXCAVATION FOR GROUND WATER SOURCE CONTROL AND NO CAP
- 10-FOOT EXCAVATION FOR GROUND WATER SOURCE CONTROL AND NO CAP
- 12-FOOT EXCAVATION FOR GROUND WATER SOURCE CONTROL AND NO CAP
- 15-FOOT EXCAVATION FOR GROUND WATER SOURCE CONTROL AND NO CAP
- EXISTING SURFACE COVER REMAINS AND IS MAINTAINED AS CAP
- EXTENT OF LNAPL EXTRACTION RECOVERY SYSTEM
- EXTENT OF LNAPL BIOREMEDIATION TREATMENT AREA
- AMENDMENT INJECTIONS USING DIRECT-PUSH
- SOIL GAS EXTRACTION AND PRESSURIZED AMENDMENT INJECTIONS
- CONTINGENT AMENDMENT INJECTIONS USING DIRECT-PUSH

NOTES:

1. PRG - PRELIMINARY REMEDIATION GOALS.
2. RDCSRS - NEW JERSEY DEPARTMENT ENVIRONMENTAL PROTECTION RESIDENTIAL DIRECT CONTACT SOIL REMEDIATION STANDARDS.
3. ALL CAPS REPRESENT ENGINEERING CONTROLS.
4. DEED NOTICES ARE TO BE ESTABLISHED AS INSTITUTIONAL CONTROLS FOR PORTIONS OF FOSTER AVENUE AND UNITED STATES AVENUE.
5. PRGs APPLY TO THE TOP 1 FOOT OF SOIL IN UNDEVELOPED AREAS.
6. TSCA-EPA TOXIC SUBSTANCE COMPLIANCE ACT (40 CFR 760) - REMOVAL OF POLYCHLORINATED BIPHENYLS (PCBs) ABOVE 50 mg/Kg.
7. EASTERN OFF-PROPERTY AREA ALTERNATIVE 2 IS ENHANCED LNAPL BIODEGRADATION AND SOIL GAS REMOVAL.
8. EASTERN OFF-PROPERTY AREA ALTERNATIVE 2 INJECTION WELLS AND SOIL GAS EXTRACTIONS WELLS TO BE INSTALLED ON THE FORMER TAVERN/SERVICE STATION PROPERTY AND ON WEST SIDE OF UNITED STATES AVENUE.
9. EASTERN OFF-PROPERTY AREA ALTERNATIVE 2 PRESSURIZED NUTRIENT INJECTION WELLS TO BE INSTALLED ALONG THE UNITED STATES AVENUE RIGHT OF WAY EAST OF UNITED STATES AVENUE AND SOUTH OF THE FORMER TAVERN/SERVICE STATION.
10. EASTERN OFF-PROPERTY AREA ALTERNATIVE 2 DIRECT-PUSH NUTRIENT INJECTIONS WOULD BE INSTALLED BENEATH PROPERTIES E-1, E-7, E-8, E-9, E-10 AND E-11 WHERE LNAPL IS PRESENT.
11. OPERATION OF A NUTRIENT INJECTION AND SOIL GAS RECOVERY SYSTEMS.

SOURCE:

1. BASEMAP, WESTON SOLUTIONS, 2016.
2. PARCELS OF CAMDEN COUNTY, NEW JERSEY 2016, CAMDEN COUNTY IMPROVEMENT AUTHORITY, 2/26/2014, GIS SHP FILE http://njgin.state.nj.us/NJ_NJGINExplorer/DataDownloads.jsp

0 70 140

SCALE: 1" = 70'

TITLE:

FIGURE 3
SOIL ALTERNATIVE 3A AND EASTERN OFF-PROPERTY AREA ALTERNATIVE 2

LOCATION:

THE SHERWIN-WILLIAMS COMPANY
FORMER MANUFACTURING PLANT
GIBBSBORO, NEW JERSEY

DATE: 7/18/2019

FILENAME: 204027_FMP_FS_SOIL_ALT3_rev1

LAYOUT: SOIL_ALT3A_REV1

THE ELM GROUP
345 WALL STREET, PRINCETON, NEW JERSEY 08540
4936 YORK ROAD, SUITE 1000, HOLICONG, PENNSYLVANIA 18928
612 MAIN STREET, BOONTON, NEW JERSEY 07005
2436 EMRICK BOULEVARD, BETHLEHEM, PENNSYLVANIA 18020
www.ExploreELM.com

Comparison of FMP Site Soil Alternatives

Soil Alternative	*Protection of Public Health and the Environment*	*Compliance with ARARs*	*Permanence and Long-Term Effectiveness*	*Reduction of Toxicity, Mobility, Volume through Treatment*	*Short Term Effectiveness*	*Implementability*	*Cost*
Alternative 1	○	○	○	◔	●	●	●
Alternative 2	◕	◑	◑	◔	◕	◕	◕
Alternative 3	●	●	◕	◑	◑	◑	◑
Alternative 3A	●	●	●	◑	◔	◔	◔
Alternative 4	●	●	●	○	○	○	○

Alternative 1 – No Action
Alternative 2 - Targeted Surface Soil Removal, Capping and Institutional Controls
Alternative 3 - Soil and LNAPL Removal/Treatment, Capping and Institutional Controls
Alternative 3A - Soil and LNAPL Removal/Treatment, Capping with Supplemental Excavation and Institutional Controls
Alternative 4 - Extensive Excavation to Depth and Institutional Controls

LEGEND

● ◕ ◑ ◔ ○

Good ------------------------→ Poor

TITLE:	FIGURE 4 EVALUATION OF SITE SOIL ALTERNATIVES
LOCATION:	FORMER MANUFACTURING PLANT SITE GIBBSBORO, CAMDEN COUNTY, NEW JERSEY
DATE:	04/26/2019
FILENAME:	2040247_FMP_ADDEN_FS_FIG_4EVAL_SOIL_ALT.VSDX

THE Elm GROUP
345 WALL STREET, PRINCETON, NEW JERSEY 08540
4936 YORK ROAD, SUITE 290, HOLICONG, PENNSYLVANIA 18928
612 MAIN STREET, 2nd FLOOR, BOONTON, NEW JERSEY 07005
2436 EMRICK BLVD, BETHLEHEM, PENNSYLVANIA 18020

G:\204027_SHERWIN-WILLIAMS_GIBBSBORO\FMP\FS\ALTERNATIVE COMPARISON FIGURES\FS_REV_1_ADDEN\2040247_FMP_ADDEN_FS_FIG_4EVAL_SOIL_ALT.VSDX\5/2/2019

Table 1
Estimated Costs for Remedial Alternatives
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

Soil and LNAPL Alternatives	Former Main Plant Area	Former Resin Plant Area and Tank Farm A	Former Lagoon Area	Seep Area	Hilliards Creek	Total Cost
Alternative 1 - No Action	$142,416					$142,416
Alternative 2 - Targeted Surface Soil Removal, Capping and Institutional Controls	$203,263	$228,783	$1,053,423	$203,263	$4,088,737	$5,777,469
Alternative 3 - Soil and LNAPL Removal/Treatment, Capping and Institutional Controls	$3,414,906	$5,751,561	$1,433,352	$7,464,315	$6,029,847	$24,093,981
Alternative 3A - Soil and LNAPL Removal/Treatment, Capping with Supplemental Excavation and Institutional Controls	$10,053,731	$5,751,561	$1,433,352	$7,464,315	$6,029,847	$30,732,806
Alternative 4 - Extensive Excavation to Depth and Institutional Controls	$14,446,188	$42,931,126	$16,297,947	$7,464,315	$6,029,847	$87,169,423

Eastern Off Property LNAPL Alternatives	
Alternative 1 - No Action	$ 142,416
Alternative 2 - Enhanced LNAPL Biodegradation and Soil Gas Removal	$ 4,480,520
Alternative 3 - Extensive Excavation to Depth	$ 18,404,357

Sediment Alternatives	
Alternative 1 - No Action	$28,483
Alternative 2 -Capping and Monitored Natural Recovery	$1,610,472
Sediment Alternative 3 - Removal of Surface Sediment with Contaminants Greater than PRGs, Capping and Natural Recovery	$1,758,649

Surface Water Alternatives	
Alternative 1 - No Action	$28,483
Alternative 2 Institutional Controls with Monitoring	$123,529

Appendix A: Response to comments on EPA Letter Dated March 11, 2019

Document/ Section	EPA Comment	Response
EPA Comments on January 11, 2019 (revised) Feasibility Study for the Former Manufacturing Plant (FMP) Area Sherwin-Williams/Hilliards Creek Superfund Site - Operable Unit 2 (Soils) Administrative Order Index No. II CERCLA-02-99-2035		
1	Alternative 3 of the FS provides for soil excavation of PCB contaminated soils and arsenic contaminated soils, which act as source areas to shallow groundwater – both in the area north of Foster Avenue. Separate from these two areas proposed for excavation, much of the other soil contamination north of Foster Avenue is proposed to be capped, utilizing the existing structures and paved surfaces. Both the current property owner (Brandywine) and the Borough of Gibbsboro have approached EPA in the past with redevelopment plans for the FMP. Although EPA is not in possession of a specific set of current redevelopment plans from either entity, it is anticipated that this area of the site will undergo intensive redevelopment. Under such circumstances, an alternative that includes broader contaminant excavation and removal from this area should be provided as a either a component of Alternative 3 or in an additional Alternative. EPA would like to discuss conditions which exist in the vicinity of the 7 Foster Avenue structure and alternatives for this area of the site.	Pursuant to EPA's March 28, 2019 letter, an additional soil alternative (Soil Alternative 3A) has been developed. This alternative is included in the comparative analysis of alternatives in the Soil FS Addendum.
2	Based on several lines of evidence it is likely that LNAPL contamination exits beneath portions of Foster Avenue. The FS report addresses the LNAPL beneath United States Avenue, as a potential contingency, and should provide detail on how the bioremediation alternative would address the LNAPL beneath portions of Foster Avenue as well.	Soil Alternatives 3 and 3A include nutrient injection wells immediately north of Foster Avenue (see Appendix E in FMP FS). It is expected that the combination of pressurized injections and southwesterly groundwater flow will transport nutrients beneath Foster Avenue to stimulate the ongoing biodegradation. This is specified in the description of Alternative 3A.
3	As previously indicated to Sherwin-Williams, EPA requires target clean up values that are applied for the excavation of source areas beneath the water table for arsenic (north of Foster Avenue) and pentachlorophenol (former lagoon area) in Soil Alternative 3.	Based on the current understanding of the distribution of arsenic and pentachlorophenol, the following criteria defining source areas have been applied: Arsenic: 50 mg/kg

Document/ Section	EPA Comment	Response
		Pentachlorophenol: 15 mg/kg Note that based on the conceptual model of partitioning in the saturated zone as the mechanism by which these constituents are transferred from the solid to dissolved phase, these values are applied in the saturated zone. Also, additional PDI sampling will be conducted prior to the remedial design and it is possible that, based on the PDI results, these values may be revised.
4	Page 22, 4th bullet on page, it is stated that, "Arsenic, lead and PAHs are present at concentrations greater than their respective IGWSRS in soil in the unsaturated zone. However, the majority of the locations are covered with an impermeable cap. Also, PAHs and lead are considered immobile chemicals under NJDEP guidance (NJDEP, 2008). Since lead and PAHs are not present in groundwater, the IGWSRS are not applicable." A more detailed discussion on the applicability of IGWSRS is needed.	Based on discussions with EPA, it is understood that no change to the FS to address this comment is required. However, where a constituent may be left in unsaturated soil at a concentration greater than the default IGWSRS, Sherwin-Williams will need to ensure in the remedial design that NJDEP requirements for exceedances of the IGWSRS are complied with. This may include installation of an impermeable cap, application of the immobile chemical guidance or development of an alternative IGWSRS.
5	EPA seeks clarification on the following statement on Page 24, 1st bullet of the page: "One location, MPSB0004, contained arsenic and lead at concentrations greater than the RDCSRS (Figure 11). The arsenic and lead were found at a depth of 3.5' – 4.0' bgs. As noted previously, lead is considered an immobile chemical pursuant to NJDEP guidance. Additionally, arsenic is not present between the 3.5' – 4.0' interval and the water table."	This statement has been removed from the FS. An errata page is included in Appendix A.
6	Page 74, incorrectly has a reference to Figure 33, should be Figure 32.	The reference on page 74 is to Figure 32. It should be Figure 33. An errata page is included in Appendix A.
7	Page 100, First sentence, top paragraph – Incorrectly cite 4 Foster Ave., when 2 Foster Avenue should be referenced.	The reference has been revised. An errata page is included in Appendix A.
8	Page 103 – Clarification is needed on statements made in the (text) portion of "Reduction of Toxicity, mobility, etc., where it is referenced	As a point of clarification, the statement does not say that Alternatives 1 and 2 would *meet* the criterion.

Document/ Section	EPA Comment	Response
	that soil Alternative 1 and 2 would meet the balancing criteria.	Rather, it states that, because there is ongoing biodegradation of the LNAPL, there would be some reduction in toxicity, mobility or volume via treatment. The evaluation also concludes, however, that Alternative 3 (and 3A in the Soil FS Addendum) score higher than Alternatives 1 and 2 because the biodegradation would be enhanced with the nutrient injection. The FS Addendum provides greater detail on this point.
9	EPA Appendix A Comment #3 Table 4b: A correlation is seen between barium and arsenic, cyanide and lead. However, while there is a correlation between barium and zinc, there is no significant correlation between barium and arsenic, lead and cyanide. This introduces potential uncertainty as to whether the remediation of arsenic, lead and cyanide in soil will be protective of terrestrial receptors (plants and soil invertebrate) from zinc in soil. Zinc is also identified as a secondary COPC for soil invertebrates in Table 8 of the March 2018 FMP BERA. Please provide additional justification for excluding a PRG calculation for zinc. Please also provide the Spearman statistical output to allow us to review against Table A.4b for zinc and barium results.	The correlations between zinc and the primary soil COPCs (arsenic, cyanide, and lead) were shown as highly correlated (high correlation coefficient), but not statistically significant in Table A.4b (*i.e.*, their respective correlation coefficients were not shown in bold). However, this was a transcription error from the statistical output. We have included the Spearman statistical output and an updated Table A.4b. As can be seen from the statistical output, correlation coefficients are high and highly statistically significant between zinc and arsenic ($r^2 = 0.88$; $p = 0.0000002$), cyanide and zinc ($r^2 = 0.90$; $p = 0.0000002$), and lead and zinc ($r^2 = 0.74$; $p = 0.0013$). Given that arsenic, barium, cyanide, lead, and zinc are all statistically significantly correlated, removal of soils with arsenic, lead, and cyanide concentrations above the wildlife PRGs is expected to reduce soil zinc concentrations to levels that are protective of all terrestrial receptors, including plants. This approach is consistent with the approach that was taken in the Burn Site and Dump Site FS reports where PRGs were not developed for terrestrial plants or invertebrates. A revised Appendix A from the FMP Soil FS is provided.

2.4.3 Former Resin Plant/Tank Farm A Area

The Former Resin Plant/Tank Farm A Area (Figure 4) is the presumed source of the LNAPL present in this area and the Seep Area south of Foster Avenue. Much of this area is covered with an impermeable cap consisting of the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings, the slab of the former "red barn" building, the parking area north of the 2 Foster Avenue building and east of the 4 Foster Avenue building, and the U.S. Avenue sidewalk. Areas not covered by an impermeable cap are the small landscaped areas around the 2 and 4 Foster Avenue buildings, the area immediately east of the historic smokestacks, located in the northernmost portion of the Former Resin Plant area, and the area between the former red barn slab and U.S. Avenue.

- ~~One location, MPSB0004, contained arsenic and lead at concentrations greater than the RDCSRS (Figure 11). The arsenic and lead were found at a depth of 3.5' – 4.0' bgs. As noted previously, lead is considered an immobile chemical pursuant to NJDEP guidance. Additionally, arsenic is not present between the 3.5' – 4.0' interval and the water table.~~

- In addition to the characteristics of the LNAPL applicable to all of the LNAPL at the FMP and Eastern Off-Property Area, there are conditions applicable to the LNAPL in this area:

  - The LNAPL extends horizontally from the former stacks located adjacent to Silver Lake in the northwest portion of the area, to U.S. Avenue to the east, and to Foster Avenue to the south;

  - Based on the presence of methane and other petroleum vapors in soil gas (Figure 5), the LNAPL is likely present beneath a portion of the 4 Foster Avenue, and all of the 3 U.S. Avenue building and 2 Foster Avenue building;

2.4.3. Former Resin Plant/Tank Farm A Area

The Former Resin Plant/Tank Farm A Area (Figure 4) is the presumed source of the LNAPL present in this area and the Seep Area south of Foster Avenue. Much of this area is covered with an impermeable cap consisting of the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings, the slab of the former "red barn" building, the parking area north of the 2 Foster Avenue building and east of the 4 Foster Avenue building, and the U.S. Avenue sidewalk. Areas not covered by an impermeable cap are the small landscaped areas around the 2 and 4 Foster Avenue buildings, the area immediately east of the historic smokestacks, located in the northernmost portion of the Former Resin Plant area, and the area between the former red barn slab and U.S. Avenue.

- In addition to the characteristics of the LNAPL applicable to all of the LNAPL at the FMP and Eastern Off-Property Area, there are conditions applicable to the LNAPL in this area:

    - The LNAPL extends horizontally from the former stacks located adjacent to Silver Lake in the northwest portion of the area, to U.S. Avenue to the east, and to Foster Avenue to the south;

    - Based on the presence of methane and other petroleum vapors in soil gas (Figure 5), the LNAPL is likely present beneath a portion of the 4 Foster Avenue, and all of the 3 U.S. Avenue building and 2 Foster Avenue building;

- Develop a site-specific IGWSRS for pentachlorophenol to support an evaluation of the need to remove any additional unsaturated soil where pentachlorophenol is present at concentrations greater than the default IGWSRS. The information needed to develop the site-specific IGWSRS would be collected as part of a PDI.

- Restore the excavation areas and maintain the existing soil cap that is present across the remainder of the former Lagoon Area.

- Conduct additional characterization within the Former Lagoon Area to identify the source of VOC/SVOC TICs in groundwater. It is expected that the results of this evaluation would be used to develop and evaluate remedial alternatives for the VOC and SVOC TICs in the groundwater FS.

Upper Hilliards Creek

- Remove all soil containing constituents greater than the PRGs in the top one foot of the Upper Hilliards Creek flood plain.

- Remove all soil at depths greater than one foot where constituents are present at concentrations greater than the RDCSRS throughout the Upper Hilliards Creek floodplain.

The extent of the remedial actions that would be conducted under Soil Alternative 3 are shown on Figure 33~~2~~. In all areas, a groundwater monitoring network would be installed following implementation of the remedial action. Detailed figures showing the conceptual design for the LNAPL remediation systems are provided in Appendix E. The bases for, and descriptions of, these additional actions are discussed below.

Former Main Plant Area

Arsenic was found in groundwater at concentrations greater than the GWQS in shallow monitoring wells MPMW0032 and MPMW00049 (Figure 2). In the area where arsenic was

- Develop a site-specific IGWSRS for pentachlorophenol to support an evaluation of the need to remove any additional unsaturated soil where pentachlorophenol is present at concentrations greater than the default IGWSRS. The information needed to develop the site-specific IGWSRS would be collected as part of a PDI.

- Restore the excavation areas and maintain the existing soil cap that is present across the remainder of the former Lagoon Area.

- Conduct additional characterization within the Former Lagoon Area to identify the source of VOC/SVOC TICs in groundwater. It is expected that the results of this evaluation would be used to develop and evaluate remedial alternatives for the VOC and SVOC TICs in the groundwater FS.

Upper Hilliards Creek

- Remove all soil containing constituents greater than the PRGs in the top one foot of the Upper Hilliards Creek flood plain.

- Remove all soil at depths greater than one foot where constituents are present at concentrations greater than the RDCSRS throughout the Upper Hilliards Creek floodplain.

The extent of the remedial actions that would be conducted under Soil Alternative 3 are shown on Figure 33. In all areas, a groundwater monitoring network would be installed following implementation of the remedial action. Detailed figures showing the conceptual design for the LNAPL remediation systems are provided in Appendix E. The bases for, and descriptions of, these additional actions are discussed below.

Former Main Plant Area

Arsenic was found in groundwater at concentrations greater than the GWQS in shallow monitoring wells MPMW0032 and MPMW00049 (Figure 2). In the area where arsenic was

LNAPL from the Seep Area, enhance LNAPL degradation in the Former Resin Plant/Tank Farm A area and implement LNAPL recovery actions beneath the 2~~4~~ Foster Avenue building and south of Foster Avenue. The biostimulation in the former Resin Plant/Tank Farm A Area would enhance biodegradation beneath Foster Avenue and the upper portion of U.S. Avenue. The LNAPL removal in the Seep Area would remove the vast majority of LNAPL, such that any remaining LNAPL beneath the 5 Foster Avenue building would biodegrade. Treatment of the LNAPL beneath the southern portion of U.S. Avenue is contemplated in a remedial alternative for the Eastern Off-Property Area.

The subsurface soil ventilation system would remove/biodegrade the methane and petroleum vapors from beneath the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings, and the associated parking areas. A Deed Notice would be established to prevent unauthorized activities in areas where constituents remain in soil at concentrations greater than the RDCSRS.

Soil Alternative 4 – Extensive Excavation to Depth, Capping and Institutional Controls would be protective of human health and ecological receptors. All surface soil containing constituents at concentrations greater than the PRGs in ecological habitat areas would be removed. All accessible subsurface soil containing constituents at concentrations greater than the RDCSRS would be removed, and, where the soil is not accessible (such as beneath Foster Avenue, U.S. Avenue and the remaining buildings), the direct contact pathway would be eliminated. Achieving the PRGs in the ecological habitat areas would also prevent transport of constituents into the water bodies. By removing all accessible subsurface soil containing constituents at concentrations greater than the RDCSRS, the sources of groundwater contamination would be addressed. A Deed Notice would be established for the areas of the property where soil remains at concentrations greater than the RDCSRS to prevent unauthorized contact.

LNAPL from the Seep Area, enhance LNAPL degradation in the Former Resin Plant/Tank Farm A area and implement LNAPL recovery actions beneath the 2 Foster Avenue building and south of Foster Avenue. The biostimulation in the former Resin Plant/Tank Farm A Area would enhance biodegradation beneath Foster Avenue and the upper portion of U.S. Avenue. The LNAPL removal in the Seep Area would remove the vast majority of LNAPL, such that any remaining LNAPL beneath the 5 Foster Avenue building would biodegrade. Treatment of the LNAPL beneath the southern portion of U.S. Avenue is contemplated in a remedial alternative for the Eastern Off-Property Area.

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Appendix A

Ecological Preliminary Remediation Goals for the Former Manufacturing Plant Site Gibbsboro, New Jersey

Table of Contents

Page

List of Tables

List of Figures

Abbreviations

95% UCL	95% Upper Confidence Level
μmol	Micromole
ac	Acre
Ag	Silver
Al	Aluminum
ARAR	Applicable or Relevant and Appropriate Requirement
As	Arsenic
AVS	Acid Volatile Sulfide
Ba	Barium
BAF	Bioaccumulation Factor
Be	Beryllium
BERA	Baseline Ecological Risk Assessment
Cd	Cadmium
CN-	Cyanide
COPC	Chemical of Potential Concern
Cr	Chromium
Cu	Copper
EPA	United States Environmental Protection Agency
FMP Area	Former Manufacturing Plant Area
f_{OC}	Fraction of Organic Carbon
FS	Feasibility Study
g_{OC}	Gram of Organic Carbon
HC	Hilliards Creek
HPAH	High Molecular Weight Polycyclic Aromatic Hydrocarbon
HQ	Hazard Quotient
LHC	Lower Hilliards Creek
LOAEL	Lowest Observed Adverse Effect Level
LOE	Line of Evidence
LOEC	Lowest Observed Effect Concentration
MHC	Middle Hilliards Creek
Mn	Manganese
mPECQ	Mean Probable Effect Concentration Quotient
Ni	Nickel
NJDEP	New Jersey Department of Environmental Protection
NOAEL	No Observed Adverse Effect Level

NOEC	No Observed Effect Concentration
Pb	Lead
PEC	Probable Effect Concentration
PECQ	Probable Effect Concentration Quotient
PRG	Preliminary Remediation Goal
Sb	Antimony
Se	Selenium
SEM	Simultaneously Extracted Metals
SQG	Sediment Quality Guideline
Tl	Thallium
TRV	Toxicity Reference Value
UHC	Upper Hilliards Creek
V	Vanadium
WOE	Weight of Evidence
Zn	Zinc

A.1 Introduction

A Baseline Ecological Risk Assessment (BERA) was conducted for the Former Manufacturing Plant Area (hereafter referred to as the FMP Area) (Gradient, 2018; US EPA Region II, 2018). The FMP Area BERA considered one ecological exposure area: Upper Hilliards Creek (UHC). This terrestrial and aquatic exposure area encompasses habitat located south of Foster Avenue, west of United States Avenue, and east of West Clementon Road, consisting of undeveloped palustrine forested wetlands along the stream course of Hilliards Creek (HC) and adjacent upland areas, including the former lagoon area (Weston, 2009). This exposure area is approximately 17.1 acres (ac) in size, with approximately 0.4 ac of stream.

Sufficient information was available to provide a thorough characterization of ecological risks at the FMP Area in the BERA (Gradient, 2018). The BERA concluded, based on a weight-of-evidence (WOE) analysis of multiple lines of evidence (LOEs), that chemicals of potential concern (COPCs) in UHC potentially pose an unacceptable ecological risk. Ecological risks identified in the BERA for key inorganic COPCs (primarily arsenic [As], lead [Pb], and cyanide [CN-]) are primarily associated with localized elevated concentrations in soil and sediment within and near HC, whereas concentrations are much lower in upland areas away from HC in the FMP Area.

This document derives ecological preliminary remediation goals (PRGs) for soil and sediment, based on the BERA (Gradient, 2018), that will be used in the Feasibility Study (FS). Specifically, this document derives PRGs for the protection of benthic invertebrates and aquatic-dependent wildlife in UHC, and PRGs for the protection of terrestrial wildlife in UHC.[1] Site-specific PRGs were not derived for soil invertebrate and terrestrial plant communities.[2]

Given that the BERA identified ecological risks primarily associated with As, Pb, and CN-, these COPCs were considered the primary COPCs that required risk management and were used for the derivation of PRGs for both sediment (Sections A.2 and A.3) and soil (Section A.4). Final proposed PRGs are presented in Section A.5. Wildlife PRGs for secondary COPCs identified in the BERA (*i.e.*, COPCs that resulted in elevated risk estimates for some ecological receptor groups for one LOE, but for which either the effect or exposure metric had substantial uncertainties) were also calculated for the most sensitive aquatic-dependent (Spotted Sandpiper) and terrestrial (American Robin and Short-Tailed Shrew) wildlife receptors (see Sections A.3 and A.4).

Ecological PRGs were derived following New Jersey Department of Environmental Protection (NJDEP) guidance for the determination of risk-based remediation goals (NJDEP, 2015). These are consistent with the risk management section (Step 8) of the United States Environmental

[1] EPA directed Sherwin-Williams to also include samples collected in Middle Hilliards Creek (MHC) and Lower Hilliards Creek (LHC) as part of the Waterbodies BERA to derive PRGs that would apply to all of HC and not just UHC.

[2] While barium (Ba) and zinc (Zn) were also identified as primary COPCs for terrestrial plants (Table 10 in FMP Area BERA; Gradient, 2018), concentrations of these two metals are significantly correlated, and they are also correlated with the primary soil COPCs for wildlife (As, Pb, and CN-), as shown in Table A.4b. Therefore, no terrestrial plant PRGs were derived for Ba and Zn. Removal of soils with As, Pb, and CN- concentrations above the wildlife PRGs is expected to reduce soil COPC concentrations to levels that are protective of all terrestrial receptors, including plants.

Protection Agency's (EPA's) Superfund ecological risk assessment guidance (US EPA, 1997). Numerical PRGs serve as delineation criteria for sediments and soils, which enable the determination of the contaminant footprint, volume of contaminated media, and potential remedial action costs (NJDEP, 2015). Benthic invertebrate PRGs were developed using the results of the sediment toxicity testing that was conducted as part of the BERA.[3] The aquatic-dependent and terrestrial wildlife PRGs were developed using food chain models and site-specific information (*e.g.*, tissue concentration data) that was collected as part of the BERA. The following sections describe how the PRGs were derived, the uncertainties associated with the PRGs (*e.g.*, toxicity reference values [TRVs]), the proposed numerical PRGs for the protection of ecological receptors present at the FMP Area, and the ecological protectiveness of the soil and sediment alternatives identified in the FS.

Site-specific surface water PRGs were not developed herein, because the New Jersey Water Quality Standards are considered Applicable or Relevant and Appropriate Requirements (ARARs) for UHC.[4]

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[3] The FMP BERA relied on several lines of evidence to evaluate risks to benthic invertebrates, including sediment chemistry, chemical bioavailability (*i.e.*, using SEM/AVS and TOC), comparison to sediment quality guidelines (*i.e.*, using mPECQ), and site-specific sediment toxicity (Gradient, 2018). Site-specific sediment toxicity testing was considered the primary line of evidence and was used for the derivation of benthic PRGs, consistent with the approach used in the Dump Site FS (Weston, 2016) and Burn Site FS (ELM, 2017).

[4] Manganese was identified as a primary COPC based on a weight-of-evidence evaluation for fish (Table 9 in FMP Area BERA; Gradient, 2018). Given that surface water is the primary environmental medium of exposure for fish and given that the New Jersey Water Quality Standards are ARARs for surface water, no site-specific PRGs were developed for manganese in surface water.

A.2 Sediment PRGs for the Protection of Benthic Invertebrates

The FMP Area BERA examined several LOEs to evaluate the potential for COPCs to adversely affect the survival, growth, or reproduction of benthic invertebrate populations in UHC (Gradient, 2018). Each LOE provided information to address the following ecological risk questions:

- Are the concentrations of COPCs in sediment, pore water, surface water, and benthic invertebrate tissue from aquatic portions of the FMP Area predicted to cause adverse effects on the survival, growth, or reproduction of benthic invertebrates?
- Is the survival or growth (*i.e.*, weight or biomass) of benthic invertebrates, as indicated by *Hyalella azteca*, exposed to bulk sediment significantly different from that of background samples (*i.e.*, a ≥20% reduction in survival or growth of organisms exposed to FMP Area sediments relative to organisms exposed to background sediments as measured in a 28-day sediment toxicity bioassay)?

Measures of exposure and effect were used to assess the above risk questions for benthic invertebrates. These included sediment, surface, and pore water chemistry; toxicity tests; and tissue chemistry.

- **Measures of Exposure:**
  - COPC concentrations in sediment (including acid volatile sulfide [AVS]/ simultaneously extracted metals [SEM])
  - COPC concentrations in pore water
  - COPC concentrations in surface water (total and dissolved)
  - COPC concentrations in invertebrate tissue
- **Measures of Effect:**
  - Literature-derived toxicity data (*i.e.*, sediment toxicity benchmarks)
  - Sediment toxicity tests (28-day growth and survival) with *Hyalella azteca*

Based on the overall WOE, there was sufficient information to conclude in the FMP Area BERA that there is the potential for unacceptable risks to benthic invertebrates in UHC (even though the sediment toxicity LOE showed no toxicity in any of the tested locations). The results of the WOE analysis provided a strong basis for identifying the primary COPCs (As, Pb, and CN-) and assessing risks to benthic invertebrates. A subset of additional sediment toxicity samples collected in MHC and LHC as part of the Waterbodies BERA found significant toxicity, indicating the potential for unacceptable risks to benthic invertebrates in these areas. At EPA's direction, the sediment toxicity samples collected in MHC and LHC as part of the Waterbodies BERA were included here and used to derive benthic PRGs that would apply to all of HC and not just UHC.

Sediment Toxicity Test and Chemistry Results

Sediment samples from 15 locations in HC and 10 locations from the background area were assessed for toxicity using a 28-day growth and mortality test with *Hyalella azteca*. A summary of the toxicity test results and co-located sediment chemistry data is presented in Table A.1. In addition to comparing measured COPC concentrations in the sediment used for toxicity testing to the sediment quality benchmarks (sediment quality guidelines [SQGs]) used in the BERA (Gradient, 2018), the sediment toxicity test responses (*i.e.,* survival and growth) were evaluated statistically (using SigmaPlot V13.0) to aid in the development of sediment PRGs (Attachment 1).

Background sediment toxicity samples did not result in significant toxicity (see Table A.1). Similarly, none of the UHC (mean survival = 94%, mean weight = 0.44 mg, mean biomass = 0.41 mg) sediment samples resulted in significant toxicity. Further, mean weight and mean biomass results were significantly greater ($p < 0.05$) in samples collected from UHC when compared to background samples (see Table A.1 and Attachment 1 for statistical output). Three sediment samples from MHC (HCBEDD21, HCBEDD23, and HCBEDD25) and one sediment sample from LHC (HCBEDD26) showed a statistically significant reduction in survival that was more than 20% lower than the average survival in the background samples. One of these four sediment samples showed no survival (HCBEDD21 in MHC). Observed weights in the MHC and LHC bioassay samples were all much greater than in the background samples. Sediment characteristics (*e.g.*, grain size, organic carbon) were comparable between UHC and the background areas (see Gradient, 2018). The organic content of samples collected in MHC and LHC were also comparable to the background areas, although some sediment locations contained higher levels of organic carbon (*i.e*., >6%).

Sediment chemistry results were also compared to SQGs to assess potential risks. The primary SQGs used in the BERA were the probable effect concentrations (PECs) developed by MacDonald *et al.* (2000). The sediment PECs represent a concentration above which adverse effects are expected to occur more often than not (MacDonald *et al*., 2000). Chemical concentrations in each sediment location were compared to the SQG. In addition, to evaluate toxicity due to mixtures, the mean probable effect concentration quotient (mPECQ) method was performed following the procedures described by the United States Geological Survey (USGS, 2000), as follows: the mPECQ is the mean exceedance of the probable effect concentration quotient (PECQ) for all COPCs for which a PEC exists, an mPECQ <0.5 is considered to have a low probability of toxicity, and an mPECQ >1.0 is associated with a moderate probability of sediment toxicity. In one sample from UHC (HCBEDD18-SD-AA-AB-0), the mPECQ, but not the AVS/SEM[5] results, suggested the potential for sediment toxicity; however, no toxicity was observed in the bioassays for that sample (Tables A.1 and A.2). In two MHC sediment samples (HCBEDD21 and HCBEDD23), the mPECQ and the AVS/SEM results suggested the potential for sediment toxicity and significant toxicity was observed. In two samples (HCBDEDD25 in MHC and HCBEDD26 in LHC), the mPECQ, but not the AVS/SEM results, suggested the potential for sediment toxicity and sediment toxicity was observed. In one sample from MHC (HCBEDD24), the mPECQ, but not the AVS/SEM results, suggested the potential for sediment

[5] The AVS/SEM benchmark relates potential sediment toxicity to seven divalent metals (cadmium [Cd], copper [Cu], chromium [Cr], Pb, nickel [Ni], silver [Ag], and Zn) as follows: sediments with AVS/SEM >0.0, but which have substantial AVS present, should not be toxic due to Cr or Ag; sediments with ΣSEM-AVS/fraction of organic carbon (f_{OC}) <130 micromoles per gram of organic carbon (μmol/g_{OC}) are expected to pose a low risk of adverse biological effects due to Cd, Cr, Cu, Pb, Ni, and Zn; sediments with ΣSEM-AVS/f_{OC} between 130 and 3,000 μmol/g_{OC} may have adverse biological effects due to Cd, Cu, Pb, Ni, or Zn; and sediments with ΣSEM-AVS/f_{OC} >3,000 μmol/g_{OC} are expected to cause adverse biological effects due to Cd, Cu, Pb, Ni, or Zn (US EPA, 2005).

toxicity; however, no toxicity was observed in the bioassay for that sample. Similarly, in one sample from LHC (HCBEDD28), the AVS/SEM, but not the mPECQ results, suggested the potential for sediment toxicity; however, no toxicity was observed in the bioassay for that sample. The field duplicate sample collected in LHC (HCBEDD26-SD-AA-AB-1) showed a very similar, statistically significant reduction in survival to that of the parent sample (HCBEDD26-SD-AA-AB-0).

Statistical correlations between the sediment metal concentrations and the toxicity responses were evaluated in Table A.3. From this analysis, it is clear that several metals (*i.e.*, Ba, chromium [Cr], CN-, and Pb) are significantly correlated with the observed survival responses. Significant correlations between most metals concentrations (including the key COPCs identified in the FMP Area BERA: As, Pb, and CN-) were observed in HC sediment (Table A.4a). This provides further support that reducing exposure associated with the primary sediment COPCs (As, Pb, and CN-) will also result in reducing exposures to the correlated secondary sediment COPCs (*e.g.*, Ba, Cr). The available sediment toxicity dataset was used to derive site-specific toxicity thresholds as described below.

Sediment Preliminary Remediation Goals

The site-specific sediment toxicity test results were considered a primary line of evidence and were used to derived benthic PRGs consistent with the approach used to derived benthic PRGs in the Dump Site FS (Weston, 2016) and Burn Site FS (ELM, 2017). Site-specific sediment PRGs were developed using the sediment data collected in the BERA as follows:

1. The highest concentration of a COPC at which no effect was observed in the toxicity bioassays (a no observed effect concentration [NOEC]); or
2. The lowest concentration of a COPC at which minimal or low toxicity was observed in the toxicity bioassays (a lowest observed effect concentration [LOEC]).

The NOEC was identified as the highest concentration from sediment samples that exhibited no significant toxicity (consistent with NJDEP, 2015). The LOEC was defined as the concentration at which an effect level of greater than 20% was observed in the bioassays. This effect level is commonly used as a *de minimis* risk level for ecological risk assessments. Suter *et al.* (2000) considered effect levels greater than 20% to be of environmental significance and changes in natural populations of less than 20% to not generally be differentiated from natural variability. Field *et al.* (2002) also considered an effect level of 20% from the control, in combination with statistical significance, to designate samples as toxic.

Four samples (three in MHC [HCBEDD21, 23, and 25] and one in LHC [HCBEDD26]) resulted in a statistically significant reduction in survival that was greater than 20% as compared to the background. No survival was observed in sample HCBEDD21. In sample HCBEDD23, there was a reduction in biomass that was not statistically significant, but greater than 20%, as compared to the background. Overall, survival was the most sensitive toxicity endpoint and it was therefore used to determine the LOEC and NOEC values. The lowest As and Pb concentrations measured in samples resulting in a greater than 20% reduction in survival, as compared to the background, were selected as the LOEC, *i.e.*, 20.7 mg/kg (As) and 812 mg/kg (Pb). The lowest CN- concentration measured in a sample resulting in a greater than 20% reduction in survival, as compared to the background, was 2.7 mg/kg (HCBEDD26). However, the next higher CN- concentration (24 mg/kg), observed at location HCBEDD23 was selected as the LOEC. While both locations showed statistically significant toxicity and a greater than 20%

reduction in survival as compared to the background, the toxicity in location HCBEDD26 was attributed to As and Pb, given that concentrations of these two metals exceed their selected LOECs (*i.e.*, 86 mg/kg of As and 1,300 mg/kg of Pb). Further, several samples with much higher CN- concentrations (≤ 19.8 mg/kg) did not result in toxicity. The next lowest As, Pb, and CN- concentrations in the HC sample dataset were selected as the PRG values (*i.e.*, 20.5 mg/kg for As, 593 mg/kg for PB, and 19.8 mg/kg for CN-; Table A.5). The selected PRG values are considered a conservative estimate of COPC concentrations not expected to result in adverse effects to the benthic invertebrate community in HC. As shown in Table A.2, several samples contain As, Pb, and CN- concentrations that exceed the selected benthic PRGs but still show acceptable survival. Given that concentrations of As, Pb, and CN- were frequently above sediment benchmarks[6] and these metals were correlated with other metals (Table A.4a), removal of sediments with As, Pb, and CN- concentrations above the proposed PRGs is expected to reduce sediment COPC concentrations to levels that are protective of benthic invertebrates.

The proposed sediment PRGs for the protection of the benthic invertebrate community in HC are: As – 20.5 mg/kg, Pb – 593 mg/kg, and CN- – 19.8 mg/kg (Table A.5).

[6] CN- does not have a PEC and therefore exceedances are not shown in Table A.2. However, Table C.6 in the FMP BERA shows that all of the five sediment sample locations in UHC had exceedances of the CN- sediment screening benchmark (*i.e.*, 0.1 mg/kg) (Gradient, 2018).

A.3 Sediment PRGs for the Protection of Aquatic-dependent Wildlife

Food web modeling was conducted in the BERA to examine potential risks to aquatic-dependent wildlife receptors that may be exposed to COPCs in UHC (Gradient, 2018). The assessment included an estimate of total dietary exposure (including prey items, surface water, and sediment ingestion) for a number of surrogate avian and mammalian aquatic-dependent wildlife receptors representing different feeding guilds (*i.e.*, Mallard, Great Blue Heron, Spotted Sandpiper, Raccoon, Mink, and Muskrat). The total dietary intake (or total dietary dose) was then compared to a TRV representing the potential for adverse effects to growth, survival, or reproduction. The following COPCs were identified as posing a potential risk to aquatic-dependent wildlife in UHC, as reported in the BERA (Gradient, 2018).

- **Mallard:** Risk results were below 1.0 for most COPCs. Only CN- yielded a hazard quotient (HQ) > 1 based on both the no observed adverse effect level (NOAEL) and lowest observed adverse effect level (LOAEL). Additionally, Pb yielded an HQ > 1 based on the NOAEL, but below 1 based on the LOAEL.
- **Great Blue Heron:** Risk results were below 1.0 for most COPCs. Only CN- yielded an HQ > 1 based on both the NOAEL and LOAEL. Additionally, Pb yielded an HQ > 1 based on the NOAEL, but below 1 based on the LOAEL.
- **Spotted Sandpiper:** Total dietary exposure for the following COPCs yielded HQs > 1 based on both the NOAEL and LOAEL: As, Ba, Cr, Cu, Pb, vanadium (V), CN-, and total high molecular weight polycyclic aromatic hydrocarbons (HPAHs). Additionally, aluminum (Al), selenium (Se), and di-n-butylphthalate yielded an HQ > 1 based on the NOAEL, but below 1 based on the LOAEL.
- **Raccoon:** Risk results for all COPCs were below 1.0.
- **Mink:** Risk results for all COPCs were below 1.0.
- **Muskrat:** Total dietary exposure for the following COPCs yielded HQs > 1 based on both the NOAEL and LOAEL: antimony (Sb), As, Cr, Pb, and thallium (Tl). Additionally, Al yielded an HQ > 1 based on the NOAEL, but below 1 based on the LOAEL.

Several sources of uncertainty related to wildlife exposure estimates, modeled tissue concentrations, and TRVs were noted in the BERA (Gradient, 2018). For example, the TRV for CN- resulted in risk estimates greater than 1 for all avian receptors. Due to the lack of chronic avian toxicity data for CN-, a TRV was developed based on an acute mortality study with a 100-fold uncertainty factor. Therefore, there is significant uncertainty in the avian risk estimates for CN-. Similarly, the mammalian TRV for Al was considered uncertain. Further, the BERA found that Al concentrations in UHC soil, surface water, and sediment were below background, indicating that risks estimated for Al are largely contributable to background.

As documented in the BERA, the most sensitive aquatic wildlife receptor was the Spotted Sandpiper. This aquatic surrogate wildlife receptor has HQs that are an order of magnitude higher than those of other aquatic surrogate wildlife receptors, has the highest modeled exposure to benthic organisms (100% of its diet), has the highest incidental sediment ingestion rate (10%), and is sensitive to the primary COPCs. Thus, for the development of wildlife sediment PRGs, the Spotted Sandpiper was selected, because it is the most sensitive surrogate aquatic wildlife receptor, and PRGs developed using this surrogate receptor will be protective of other aquatic wildlife. Sediment wildlife PRGs were developed using the BERA food web models (Gradient, 2018), consistent with NJDEP guidance (NJDEP, 2015).

The PRG calculation below incorporates site-specific and receptor-specific exposures as well as receptor feeding preferences, as described in the BERA (Gradient, 2018). This calculation is performed to estimate the sediment concentration that yields an HQ of 1.0, a value that is intended to represent *de minimis* risk.

$$Sediment\ Concentration\ \left(\frac{mg}{kg}\right) = \frac{(HQ \times TRV)}{\left[\left(FIR \times BAF \times ABS_{food}\right) + (SIR \times ABS_s)\right] \times AUF}$$

where:

HQ	=	Hazard Quotient (unitless, 1.0)
TRV	=	Toxicity Reference Value, representing a daily dose that will result in minimal adverse effects (mg/kg body weight/day)
FIR	=	Food Ingestion Rate (kg food dry weight/body weight/day), calculated based on food ingestion rates and body weights as reported in Appendix D of the BERA (Gradient, 2018)
BAF	=	Sediment Bioaccumulation Factor (unitless)
ABS_{food}	=	Bioavailable Fraction Absorbed from Ingested Prey Items (unitless)
SIR	=	Sediment Ingestion Rate (10% of food ingestion rate)
ABS_s	=	Bioavailable Fraction Absorbed from Ingested Sediment (unitless)
AUF	=	Area Use Factor (unitless), fraction of time that a receptor spends foraging in the exposure area relative to the entire home range (assumed to be 1.0)

All the parameters in the above equation are based on the assumptions provided in the BERA, except for food concentration and bioavailability assumptions (see Table A.6 for a summary of the exposure parameters). All the TRVs used were as reported in Appendix D (Table D.3) of the BERA (Gradient, 2018).

The diet of the Spotted Sandpiper is assumed to consist of 100% benthic invertebrates. Therefore, a site-specific bioaccumulation factor (BAF) was used to estimate COPC uptake from sediment into benthic invertebrate tissues. A median BAF was calculated using individual BAFs from the paired sediment and benthic invertebrate tissues collected from all of HC (including tissues collected from UHC, Middle Hilliards Creek [MHC], and Lower Hilliards Creek [LHC]), comprising three samples of snails, four samples of clams, five samples of crayfish, and three samples of assorted macroinvertebrates (shown in in Table A.7). The BAFs for each paired sediment-tissue sample and the median BAFs are presented in Table A.7. Given the similarity in COPCs, the fact that MHC and LHC are immediately downstream of UHC and part of the same stream, and the limited sample size, it was deemed appropriate to combine the UHC, MHC, and LHC sediment-tissue datasets for the purpose of deriving site-specific BAFs for UHC. Table A.7 shows median BAFs for UHC (N = 5), MHC (N = 5), LHC (N = 5), as well as all of HC (N = 15). Some locations included a duplicate sample, which was averaged with the parent sample in order to estimate a sample-specific BAF. The sediment-tissue data collected from UHC location 20 (snail and crayfish tissue samples) appear to be outliers when compared to sediment-tissue data and median BAFs collected from elsewhere in HC and in prior BERAs (Dump Site and Burn Site; Gradient 2015, 2016). Figures 1-4 illustrate how the sediment-tissue data collected from UHC location 20 skew the dataset and how median BAFs without including the UHC location 20 sediment-tissue data were used to derive PRGs. For completeness, median BAFs and the resulting wildlife PRGs using only UHC, all of HC, and all of HC minus UHC location 20, are shown in Table A.7 and Table A.9, respectively.

The wildlife sediment PRGs, based on the most sensitive aquatic wildlife receptor (the Spotted Sandpiper) are described for each key COPC below (see also Table A.9).

- **Arsenic:** The PRG for As is estimated as 17 mg/kg
- **Lead:** The PRG for Pb is estimated as 176 mg/kg
- **Cyanide:** The PRG for CN- is estimated as 3.8 mg/kg

Wildlife PRGs were also derived for the secondary metal COPCs identified in the BERA (see Table A.9). The secondary COPCs are chemicals that may have an elevated risk estimated from one or more LOEs, but either the effect or exposure metric had substantial uncertainties. As shown in Table A.4a, some of these secondary metal COPCs were not correlated with the concentrations of the primary COPCs, may be representative of background or other sources (*e.g.*, Al, beryllium [Be]), and/or their risk estimates carry significant uncertainty. As a result, the sediment wildlife PRGs presented for secondary metal COPCs were not considered for remedial decision-making, but are presented for informational purposes.

The proposed sediment PRGs for the protection of aquatic-dependent wildlife are: As – 17 mg/kg, Pb – 176 mg/kg, and CN- – 3.8 mg/kg (Table A.10).

A.4 Soil PRGs for the Protection of Terrestrial Wildlife

Food web modeling was conducted in the BERA to examine potential risks to terrestrial wildlife receptors that may be exposed to COPCs in the UHC exposure area (Gradient, 2018). The assessment included an estimate of total dietary exposure (including prey items, surface water, and soil ingestion) for a number of surrogate avian and mammalian terrestrial receptors (American Robin, Northern Bobwhite, Red-Tailed Hawk, Short-Tailed Shrew, Meadow Vole, Red Fox, and Raccoon). The total dietary intake (or total dietary dose) was then compared to a TRV representing the potential for adverse effects to growth, survival, or reproduction. The following COPCs were identified as posing a potential risk to terrestrial wildlife, as reported in the BERA (Gradient, 2018).

- **American Robin:** Total dietary exposure for several inorganic COPCs (As, Ba, Cr, Pb, Se, V, and CN-) and total HPAHs yielded HQs > 1 based on both the NOAEL and LOAEL. In addition, Al, Cd, Cu, and di-n-butylphthalate yielded HQs > 1 based on the NOAEL, but below 1 based on the LOAEL.
- **Northern Bobwhite:** Total dietary exposure for several inorganic COPCs (As, Cr, Pb, and CN-) and total HPAHs yielded HQs > 1 based on both the NOAEL and LOAEL. In addition, Al, Ba, and V yielded HQs > 1 based on the NOAEL, but below 1 based on the LOAEL.
- **Red-Tailed Hawk:** Risk results were below 1.0 for most COPCs. Only CN- yielded an HQ > 1 based on the NOAEL, but the HQ was below 1 based on the LOAEL.
- **Short-Tailed Shrew:** Total dietary exposure for several inorganic COPCs (Al, Sb, As, Ba, Cr, Cu, Pb, manganese [Mn], and Se) yielded HQs > 1 based on both the NOAEL and LOAEL. In addition, the following COPCs yielded HQs > 1 based on the NOAEL, but below 1 based on the LOAEL: Cd, Tl, total HPAHs, and 1,2-dichlorobenzene.
- **Meadow Vole:** Risk results were greater than 1.0 for several inorganic COPCs. Only Al yielded an HQ > 1 based on both the NOAEL and LOAEL. Additionally, Sb, As, Pb, Aroclor-1248, 4-chloroaniline, atrazine, and total HPAHs yielded HQs > 1 based on the NOAEL, but below 1 based on the LOAEL.
- **Red Fox:** Risk results were below 1.0 for all COPCs, except Al, which yielded an HQ > 1 based on the NOAEL, but below 1 based on the LOAEL.
- **Raccoon:** Risk results for all COPCs were below 1.0.

Several sources of uncertainty related to the wildlife exposure estimates, modeled tissue concentrations, and TRVs were noted in the BERA (Gradient, 2018). As noted in Section A.3, CN- risk estimates for avian receptors are uncertain due to an uncertain TRV. Furthermore, Al risk estimates are considered uncertain and largely attributable to background.

As documented in the BERA, the most sensitive terrestrial surrogate wildlife receptors were the American Robin and Short-Tailed Shrew (Gradient, 2018). These receptors have HQs that are similar to or an order of magnitude higher than those of other terrestrial surrogate wildlife receptors, have the highest modeled exposure to soil invertebrates (100% of its diet), have substantial incidental soil ingestion rates (2.4-10.4%), have small home ranges, and are sensitive to the primary COPCs. Thus, for the development of wildlife PRGs, the American Robin and Short-Tailed Shrew were selected, because they are the most sensitive terrestrial surrogate wildlife receptors, and PRGs developed using these surrogate receptors will be protective of other terrestrial wildlife. Wildlife PRGs were developed using the BERA food web models (Gradient, 2018), consistent with NJDEP guidance (NJDEP, 2015).

The PRG calculation below incorporates site-specific and receptor-specific exposure and feeding preferences, as described in the BERA (Gradient, 2018). This calculation is performed to estimate the soil concentration that yields an HQ of 1.0, a value that is intended to represent *de minimis* risk.

$$Soil\ Concentration\ \left(\frac{mg}{kg}\right) = \frac{(HQ \times TRV)}{\left[\left(FIR \times BAF \times ABS_{food}\right) + (SIR \times ABS_s)\right] \times AUF}$$

where:

HQ	=	Hazard Quotient (unitless, 1.0)
TRV	=	Toxicity Reference Value, representing a daily dose that will result in minimal adverse effects (mg/kg body weight/day)
FIR	=	Food Ingestion Rate (kg food dry weight/body weight/day), calculated based on food ingestion rates and body weights as reported in Appendix D of the BERA (Gradient, 2018)
BAF	=	Soil Bioaccumulation Factor (unitless)
ABS_{food}	=	Bioavailable Fraction Absorbed from Ingested Prey Items (unitless)
SIR	=	Soil Ingestion Rate (percentage of food ingestion rate)
ABS_s	=	Bioavailable Fraction Absorbed from Ingested Sediment (unitless)
AUF	=	Area Use Factor (unitless), fraction of time that a receptor spends foraging in the exposure area relative to the entire home range (assumed to be 1.0)

All the parameters in the above equation are based on the assumptions provided in the BERA, except for food concentrations. All the TRVs used were as reported in Appendix D (Table D.3) of the BERA (Gradient, 2018).

The diets of the American Robin and Short-Tailed Shrew consist of 100% soil invertebrates. Therefore, site-specific BAFs were used to estimate uptake from the soil to soil invertebrates (*i.e.*, earthworms). A median BAF (consistent with the approach used for benthic invertebrates, see Section A.3) was calculated using individual BAFs from 15 paired soil and soil invertebrate (earthworm) tissue samples collected from all of HC (including five tissues each collected from UHC, MHC, and LHC; see Table A.8). Some locations included a duplicate sample, which was averaged with the parent sample in order to estimate a sample-specific BAF. Given the similarity in COPCs, the fact that MHC and LHC upland areas are similar in habitat and contiguous with upland areas in UHC, and the limited sample size, it was deemed appropriate to combine the UHC, MHC, and LHC soil-tissue datasets for the purpose of deriving site-specific BAFs for UHC. The median BAF using all 15 sample-specific BAFs was used in the PRG calculations. For completeness, median BAFs and the resulting wildlife PRGs using only UHC and all of HC are shown in Table A.8 and Table A.9, respectively.

The wildlife soil PRGs based on the most sensitive terrestrial wildlife receptors are described for each key COPC below (see also Table A.9).

- **Arsenic:** The lowest PRG for As is estimated as 12 mg/kg (based on the Short-Tailed Shrew). This value is below the site-specific 95% upper confidence level (UCL) background soil concentration; thus, the background value of 17 mg/kg for As was selected as the PRG (Table A.10).
- **Lead:** The lowest PRG for Pb is estimated as 91 mg/kg (based on the Short-Tailed Shrew). This value is also below the site-specific 95% UCL background soil concentration; thus, the background value of 213 mg/kg for Pb was selected as the PRG (Table A.10).
- **Cyanide:** The lowest PRG for CN- is estimated as 4 mg/kg (based on the American Robin). This value is also below the site-specific 95% UCL background soil concentration; thus, the background value of 58 mg/kg for CN- was selected as the PRG (Table A.10).

Wildlife PRGs were also derived for the secondary metal COPCs identified in the BERA (see Table A.9). The secondary metal COPCs are chemicals that may have an elevated risk estimated from one or more LOEs, but for which either the effect or exposure metric has substantial uncertainties. As a result, the soil wildlife PRGs presented for secondary metal COPCs were not considered for remedial decision-making, but are presented for informational purposes in Table A.9.

The proposed soil PRGs for the protection of terrestrial wildlife are: As – 17 mg/kg, Pb – 213 mg/kg, and CN- – 58 mg/kg (Table A.10).[7]

[7] While Ba and Zn were also identified as primary COPCs for terrestrial plants (Table 10 in FMP Area BERA; Gradient, 2018), concentrations of these two metals are significantly correlated, and they are also correlated with the primary soil COPCs for wildlife (As, Pb, and CN-), as shown in Table A.4b. Therefore, no terrestrial plant PRGs were derived for Ba and Zn. Removal of soils with As, Pb, and CN- concentrations above the wildlife PRGs is expected to reduce soil COPC concentrations to levels that are protective of all terrestrial receptors, including plants.

A.5 Proposed Ecological PRGs

Table A.10 presents a summary of the proposed benthic invertebrate and wildlife sediment and the soil PRGs developed in the previous sections. These values were compared to site-specific background concentrations, which resulted in the following final proposed PRGs.

- **Sediment:**
  - As – 17 mg/kg
  - Pb – 176 mg/kg
  - CN- – 3.8 mg/kg
- **Soil:**
  - As – 17 mg/kg
  - Pb – 213 mg/kg
  - CN- – 58 mg/kg

These values are intended to be protective of ecological receptors potentially exposed to COPCs in soils and sediment at the FMP Area. Note that, for sediment, the benthic invertebrate PRGs are considered more robust than the aquatic-dependent wildlife PRGs. This is due to the multiple lines of site-specific evidence (toxicity, chemistry, and bioavailability) available for benthic invertebrates that are expected to more closely reflect site conditions. By comparison, the wildlife PRGs incorporate several generic and intentionally conservative assumptions, resulting in greater uncertainty. Furthermore, the benthic sediment PRG values apply to small areal exposures, given that benthic organisms are typically sessile, whereas wildlife exposures occur over the entire foraging area of the receptor.

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Tables

Table A.1 Summary of Sediment Lines of Evidence for Benthic Invertebrates in Hilliards Creek

Sample ID	*H. azteca*, 28-Day Survival/Growth						f_{OC}	∑SEM-AVS/f_{OC} (µmol/g_{OC})	mPECQ Metals[b]	Sediment Concentrations (mg/kg)		
	Survival		Mean Replicate Weight		Mean Replicate Biomass							
	Value (%)	RR[a]	Value (mg)	RR[a]	Value (mg)	RR[a]				As	Pb	CN-
Background Area												
BKBEDD11	92	97%	0.33	130%	0.29	121%	3.47%	-3.73	0.09	2.7	29.2	0.87 U
BKBEDD11_Dup	91	96%	0.29	114%	0.26	109%	3.08%	4.06	0.08	2.5	28.7	0.85 U
BKBEDD12	92	97%	0.26	102%	0.24	102%	0.91%	9.0	0.04	0.78 J	9.8	0.68 U
BKBEDD13	97	102%	0.21	83%	0.21	88%	0.15%	-50.9	0.02	0.37 J	6.1	0.6 U
BKBEDD14	89	94%	0.23	91%	0.2	84%	1.34%	2.57	0.03	0.74 J	11.3	0.71 U
BKBEDD15	96	101%	0.28	110%	0.27	113%	0.46%	-9.65	0.03	0.34 J	9	0.54 U
BKBEDD16	96	101%	0.22	87%	0.21	88%	2.07%	-5.02	0.04	1.1 J	8.2	0.76 U
BKBEDD17	94	99%	0.28	110%	0.26	109%	3.43%	4.21	0.10	3.1 J	39.4 J	0.84 UJ
BKBEDD18	97	102%	0.25	98%	0.24	100%	3.40%	1.04	0.06	1.6	18.1	0.7 U
BKBEDD19	100	105%	0.24	94%	0.24	100%	2.24%	2.41	0.05	1.4 U	16.6	0.56 U
BKBEDD20	97	102%	0.24	94%	0.23	96%	2.70%	5.98	0.06	1.7	21.8	0.65 U
Pooled[c]	95		0.25		0.24		2.02%	-4.41	0.05	1.3	17.0	0.3
Upper Hilliards Creek (UHC)												
HCBEDD16-SD-AA-AB-0	94	99%	0.38	148%	0.35	148%	1.96%	-130	0.16	7.7	67.6 J	6.1 J
HCBEDD16-SD-AA-AB-1	NA[d]	NA	NA[d]	NA	NA[d]	NA	1.46%	-129	0.23	9.1	134 J	3.5 J
HCBEDD17-SD-AA-AB-0	92	97%	0.47	185%	0.43	181%	2.33%	85	0.42	15.8	170	5.1
HCBEDD18-SD-AA-AB-0	95	100%	0.47	183%	0.44	183%	2.27%	-417	**1.2**	36.5	593	19.8
HCBEDD19-SD-AA-AB-0	93	98%	0.41	159%	0.38	158%	3.98%	42	0.92	43.0	452	10.9
HCBEDD20-SD-AA-AB-0	96	101%	0.47	183%	0.44	186%	1.77%	79	0.37	12.8	226	1.8 J
Middle Hilliards Creek (MHC)												
HCBEDD21-SD-AA-AB-0	**0**	**0%** *	-	-	-	-	3.83%	**2606**	**14**	114	12200 J	153
HCBEDD22-SD-AA-AB-0	96	101%	0.45	176%	0.43	178%	2.48%	-57	0.72	68.3 J	207 J	0.75 J
HCBEDD23-SD-AA-AB-0	**16**	**17%** *	0.51	200%	0.083	35%	2.26%	**205**	**1.1**	20.7	812	24[e]
HCBEDD24-SD-AA-AB-0	93	98%	0.39	154%	0.37	153%	7.28%	64	**1.4**	53.2 J	989 J	9.9 J
HCBEDD25-SD-AA-AB-0	**74**	**78%** *	0.47	185%	0.341	142%	7.15%	-8.2	**4.2**	108	3210	46.7
Lower Hilliards Creek (LHC)												
HCBEDD26-SD-AA-AB-0	**56**	**59%** *	0.66	259%	0.34	144%	4.06%	19	**1.9**	86.1 J	1300 J	2.7[e]
HCBEDD26-SD-AA-AB-1	**57**	**60%** *	0.69	273%	0.39	163%	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
HCBEDD27-SD-AA-AB-0	88	93%	0.43	170%	0.37	155%	0.52%	92	0.71	17.2	517	4.2
HCBEDD28-SD-AA-AB-0	94	99%	0.43	169%	0.40	167%	1.34%	**150**	0.70	65.7	375	0.64 U
HCBEDD29-SD-AA-AB-0	87	92%	0.46	181%	0.40	165%	6.25%	-65	0.38	20.5	111	1.3 U
HCBEDD30-SD-AA-AB-0	95	100%	0.46	182%	0.44	183%	1.90%	67	0.23	8.2	106	0.75 U

Notes:

µmol – Micromole; ANOVA – Analysis of Variance; As – Arsenic; AVS – Acid-Volatile Sulfide; BERA – Baseline Ecological Risk Assessment; Cd – Cadmium; CN- – Cyanide; Cr – Chromium; Cu – Copper; f_{OC} – Fraction of Total Organic Carbon; g_{OC} – Gram of Organic Carbon; Hg – Mercury; LHC – Lower Hilliards Creek; MHC – Middle Hilliards Creek; NA – Not Applicable; Ni – Nickel; Pb – Lead; mPECQ – Mean Probable Effect Concentration Quotient; SEM – Simultaneously Extracted Metals; UHC – Upper Hilliards Creek; Zn – Zinc.

Data Qualifiers:

J – Estimated value.

U – Undetected.

Field Sample IDs that end in "dup" or "-1" are field duplicates.

***** Statistically significant reduction in survival compared to the background based on a Kruskal-Wallis ANOVA followed by Dunn's test ($p < 0.05$; see Attachment 1). All samples that were statistically significantly lower compared to the background were also statistically significantly lower as compared to the laboratory control, with one exception. Biomass in sample HCBEDD23 was statistically significantly lower as compared to the laboratory control, but not as compared to the background. See Aquatec Environmental [2017] for statistical output, included with the FMP BERA (Gradient, 2018).

Bolded/dark shaded values indicate a potential adverse effect (see Gradient [2018] for details on these results).

(a) RR = Relative response of sample compared to background mean values.

(b) mPECQ for metals includes the following metals: As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn (see Table A.2).

(c) Pooled background represents the mean of the replicates from 10 samples (excluding the duplicate sample) from the reference area.

(d) A field duplicate sample for chemistry was collected at "HCBEDD16," however, no duplicate sediment toxicity testing was performed at this location. Rather, a duplicate sample for sediment toxicity testing was collected from a different location in LHC ("HCBEDD26").

(e) The LOEC for CN- was selected as 24 mg/kg instead of 2.7 mg/kg. While both locations HCBEDD23 and HCBEDD26 showed statistically significant toxicity, the toxicity in location HCBEDD26 is attributed to As and Pb, given that concentrations of these metals exceed their selected LOECs. By comparison, the CN- concentration at location HCBEDD26 (*i.e.*, 2.7 mg/kg) is lower than observed in six other sampled locations (3.5-19.8 mg/kg) where toxicity was not observed. Therefore, CN- is unlikely to have caused the observed toxicity at location HCBEDD26, and the CN- concentration at location HCBEDD23 was used as the LOEC.

Table A.2 Comparison of Hilliards Creek Sediment Metals Concentrations to Sediment PECs

Location Sample ID	Sample Date	Mean	As		PECQ	Cd		PECQ	Cr		PECQ	Cu		PECQ	Hg		PECQ	Ni		PECQ	Pb		PECQ	Zn		PECQ
		PECQ	mg/kg	Q	33	mg/kg	Q	4.98	mg/kg	Q	111	mg/kg	Q	149	mg/kg	Q	1.06	mg/kg	Q	49	mg/kg	Q	128	mg/kg	Q	459
Background Area																										
BKBEDD11-SD-AA-AB-0	10/13/2014	0.09	2.7		0.08	0.66	J	0.13	3.7		0.03	3.5	J	0.02	0.17	U	0.08	3.3	J	0.07	29.2		0.23	27.7		0.06
BKBEDD11-SD-AA-AB-1	10/13/2014	0.08	2.5		0.08	0.6	J	0.12	3.5		0.03	3	J	0.02	0.17	U	0.08	2.7	J	0.06	28.7		0.22	24.8		0.05
BKBEDD12-SD-AA-AB-0	10/13/2014	0.04	0.78	J	0.02	0.24	J	0.05	4.3		0.04	1.1	J	0.01	0.13	U	0.06	0.8	J	0.02	9.8		0.08	9.4		0.02
BKBEDD13-SD-AA-AB-0	10/14/2014	0.02	0.37	J	0.01	0.17	J	0.03	2.3		0.02	0.47	J	0.00	0.12	U	0.06	0.35	J	0.01	6.1		0.05	2.2	J	0.00
BKBEDD14-SD-AA-AB-0	10/14/2014	0.03	0.74	J	0.02	0.12	J	0.02	3.2		0.03	1.2	J	0.01	0.14	U	0.07	0.58	J	0.01	11.3		0.09	7.2		0.02
BKBEDD15-SD-AA-AB-0	10/14/2014	0.03	0.34	J	0.01	0.14	J	0.03	2.1		0.02	0.61	J	0.00	0.1	U	0.05	0.56	J	0.01	9		0.07	5.1	J	0.01
BKBEDD16-SD-AA-AB-0	10/14/2014	0.04	1.1	J	0.03	0.38	J	0.08	4.8		0.04	1.1	J	0.01	0.15	U	0.07	0.97	J	0.02	8.2		0.06	5.7	J	0.01
BKBEDD17-SD-AA-AB-0	10/14/2014	0.10	3.1	J	0.09	0.45	J	0.09	5.4	J	0.05	5.1	J	0.03	0.19	UJ	0.09	3.3	J	0.07	39.4	J	0.31	25.6	J	0.06
BKBEDD18-SD-AA-AB-0	10/14/2014	0.06	1.6		0.05	0.28	J	0.06	4.2		0.04	2.3	J	0.02	0.15	U	0.07	3.4	J	0.07	18.1		0.14	15.1		0.03
BKBEDD19-SD-AA-AB-0	10/15/2014	0.05	1.4	U	0.02	0.7	U	0.07	3.8		0.03	1.9	J	0.01	0.14	U	0.07	1.8	J	0.04	16.6		0.13	10.8		0.02
BKBEDD20-SD-AA-AB-0	10/15/2014	0.06	1.7		0.05	0.25	J	0.05	5.3		0.05	2.6	J	0.02	0.15	U	0.07	2.7	J	0.06	21.8		0.17	20.1		0.04
Upper Hilliards Creek (UHC)																										
HCBEDD16-SD-AA-AB-0	8/7/2017	0.16	7.7		0.23	0.21	J	0.04	15		0.14	9.3		0.06	0.094	J	0.09	2.1		0.04	67.6	J	0.53	72.6		0.16
HCBEDD16-SD-AA-AB-1	8/7/2017	0.23	9.1		0.28	0.27	J	0.05	14.7		0.13	10.6		0.07	0.037	J	0.03	2.1		0.04	134	J	**1.0**	101		0.22
HCBEDD17-SD-AA-AB-0	8/7/2017	0.42	15.8		0.48	0.43	J	0.09	15.7		0.14	24.4		0.16	0.67		0.63	4.1		0.08	170		**1.3**	209		0.46
HCBEDD18-SD-AA-AB-0	8/7/2017	**1.2**	36.5		**1.1**	0.61	J	0.12	207		**1.9**	34.5		0.23	1.1		**1.0**	3.2		0.07	593		**4.6**	217		0.47
HCBEDD19-SD-AA-AB-0	8/7/2017	0.92	43		**1.3**	1.2		0.24	142		**1.3**	22.4		0.15	0.28		0.26	2.3		0.05	452		**3.5**	252		0.55
HCBEDD20-SD-AA-AB-0	8/7/2017	0.37	12.8		0.39	0.26	J	0.05	37.7	J	0.34	9.4		0.06	0.19		0.18	1.1		0.02	226		**1.8**	69.2	J	0.15
HCBEDDUH-SD-AA-AB-0	9/6/2017	0.47	13.4		0.41	0.49	J	0.10	23.5		0.21	19.4	J	0.13	0.4		0.38	2.2	J	0.05	266	J	**2.1**	180		0.39
Middle Hilliards Creek (MHC)																										
HCBEDD21-SD-AA-AB-0	8/16/2017	**14**	114		**3.5**	4.6		0.92	1310		**12**	77.5		0.52	0.47		0.44	2.1		0.04	12200	J	**95**	366		0.80
HCBEDD22-SD-AA-AB-0	8/16/2017	0.72	68.3	J	**2.1**	2.7	J	0.54	38.7	J	0.35	32.7	J	0.22	0.052	J	0.05	9.6	J	0.20	207	J	**1.6**	323	J	0.70
HCBEDD23-SD-AA-AB-0	8/15/2017	**1.1**	20.7		0.63	0.39	J	0.08	152		**1.4**	20.9		0.14	0.19		0.18	2.3		0.05	812		**6**	101		0.22
HCBEDD24-SD-AA-AB-0	8/15/2017	**1.4**	53.2	J	**1.6**	0.95	J	0.19	116		**1.0**	21.7	J	0.15	0.14	J	0.13	3.5	J	0.07	989	J	**8**	114	J	0.25
HCBEDD25-SD-AA-AB-0	8/15/2017	**4.2**	108		**3.3**	1.1		0.22	415		**3.7**	45.1		0.30	0.19		0.18	3.8		0.08	3210		**25**	168		0.37
Lower Hilliards Creek (LHC)																										
HCBEDD26-SD-AA-AB-0	8/14/2017	**1.9**	86.1	J	**2.6**	0.54	J	0.11	132	J	**1.2**	65.5		0.44	0.094	J	0.09	3.6		0.07	1300	J	**10**	84.2		0.18
HCBEDD27-SD-AA-AB-0	8/14/2017	0.71	17.2		0.52	0.32	J	0.06	85.3	J	0.77	13.5		0.09	0.048	J	0.05	1.2		0.02	517		**4.0**	42.2		0.09
HCBEDD28-SD-AA-AB-0	8/14/2017	0.70	65.7		**2.0**	0.28	J	0.06	39.7	J	0.36	11.7		0.08	0.028	J	0.03	1.5		0.03	375		**2.9**	42.1		0.09
HCBEDD29-SD-AA-AB-0	8/14/2017	0.38	20.5		0.62	1.9		0.38	20.6	J	0.19	32.1		0.22	0.16	J	0.15	8.9		0.18	111		0.87	193		0.42
HCBEDD30-SD-AA-AB-0	8/14/2017	0.23	8.2		0.25	0.62	J	0.12	11	J	0.10	18.3		0.12	0.055	J	0.05	3.1		0.06	106		0.83	145		0.32

Notes:

As – Arsenic; Cd – Cadmium; Cr – Chromium; Cu – Copper; Hg – Mercury; LHC – Lower Hilliards Creek; MHC – Middle Hilliards Creek; mPECQ – Mean Probable Effect Concentration Quotient; Ni – Nickel; Pb – Lead; PEC – Probable Effect Concentration; PECQ – Probable Effect Concentration Quotient; UHC – Upper Hilliards Creek; Zn – Zinc.

Field Sample IDs that end in "-1" are field duplicates.

Units of mPECQs and PECQs are mg/kg.

mPECQ > 1.0 indicates a moderate probability (>50%) of sediment toxicity.

Q – Data Qualifier:

U – Undetected. The detection limit (DL) is presented. The PECQ was calculated using half the DL.

J – Estimated.

Bolded/dark shaded values indicate a concentration greater than the sediment PEC (PECs from MacDonald *et al.,* 2000) or a mPECQ greater than 1.0.

Table A.3 Statistical Correlations for Hilliards Creek Sediment Toxicity Test Results

Parameter	*H. azteca*, 28-Day Survival/Growth					
	Survival		Mean Weight		Mean Biomass	
	Correlation[a,b]	*p* Value	Correlation	*p* Value	Correlation	*p* Value
f_{OC} (%)	-0.405	0.131	0.130	0.648	-0.367	0.189
mPECQ (metals)	**-0.570**	**0.025**	0.367	0.189	-0.490	0.072
∑SEM-AVS/f_{OC} (µmol/g_{OC})	-0.366	0.176	0.141	0.615	-0.059	0.832
Aluminum	-0.231	0.396	0.167	0.552	-0.099	0.727
Antimony	0.204	0.457	0.110	0.693	0.416	0.134
Arsenic	-0.423	0.113	0.216	0.444	-0.376	0.178
Barium	**-0.552**	**0.031**	0.378	0.173	-0.424	0.125
Beryllium	0.330	0.224	0.044	0.868	0.446	0.105
Cadmium	-0.235	0.388	0.020	0.940	-0.002	0.988
Chromium	**-0.527**	**0.041**	0.323	0.251	-0.442	0.109
Cobalt	0.117	0.667	-0.064	0.820	0.079	0.773
Copper	-0.471	0.073	**0.535**	**0.047**	-0.152	0.594
Cyanide	**-0.513**	**0.048**	0.198	0.482	-0.495	0.069
Iron	-0.074	0.783	0.139	0.626	0.077	0.785
Lead	**-0.600**	**0.018**	0.398	0.152	-0.512	0.059
Manganese	-0.022	0.934	-0.330	0.238	-0.191	0.501
Mercury	-0.233	0.396	0.381	0.173	0.124	0.659
Nickel	-0.090	0.743	0.286	0.308	-0.059	0.832
Selenium	0.275	0.312	-0.262	0.356	0.156	0.583
Silver	0.116	0.676	-0.302	0.286	0.253	0.373
Thallium	0.206	0.449	-0.132	0.637	0.225	0.425
Vanadium	0.452	0.086	-0.189	0.501	0.437	0.113
Zinc	-0.086	0.753	0.092	0.738	0.218	0.444

Notes:

µmol – Micromole; AVS – Acid-Volatile Sulfide; f_{OC} – Fraction of Total Organic Carbon; g_{OC} – Gram of Organic Carbon; HC – Hilliards Creek; mPECQ – Mean Probable Effect Concentration Quotient; SEM – Simultaneously Extracted Metals.

(a) Correlations performed on 15 primary HC sediment samples combined (no field duplicates). Half of the detection limit was substituted for non-detected samples.

(b) Correlation coefficient (r2) estimate is based on Spearman rank non-parametric correlation (**bolded** values are significant, $p < 0.05$).

Table A.4a Correlation Between Variables in 2017 Hilliards Creek Sediment Samples

Parameter[a,b]	f_{OC}	Al	Sb	As	Ba	Be	Cd	Cr	Co	Cu	CN-	Fe	Pb	Mn	Hg	Ni	Se	Ag	Tl	V	Zn
f_{OC}		**0.80**	0.057	**0.56**	**0.64**	0.25	**0.70**	0.38	0.45	**0.70**	0.38	**0.72**	0.41	**0.59**	0.35	**0.70**	-0.19	-0.20	0.31	0.30	**0.55**
Al	**0.80**		-0.095	**0.58**	**0.65**	0.43	**0.87**	0.27	0.34	**0.71**	0.079	**0.83**	0.31	0.40	0.11	**0.71**	0.19	0.23	**0.71**	0.40	**0.61**
Sb	0.057	-0.095		-0.093	0.13	0.22	0.12	0.12	-0.014	0.15	0.47	0.17	-0.014	0.11	**0.76**	-0.059	-0.14	-0.31	-0.088	0.14	**0.53**
As	**0.56**	**0.58**	-0.093		**0.72**	-0.13	**0.59**	**0.76**	-0.048	**0.74**	0.35	0.51	**0.78**	0.19	0.068	0.28	0.093	0.23	0.29	-0.33	0.37
Ba	**0.64**	**0.65**	0.13	**0.72**		0.11	**0.64**	**0.82**	0.14	**0.74**	**0.69**	**0.64**	**0.78**	0.28	0.44	0.35	-0.056	0.11	0.29	-0.17	**0.53**
Be	0.25	0.43	0.22	-0.13	0.11		0.26	-0.32	0.45	0.13	-0.25	0.42	-0.24	0.42	0.093	0.45	0.13	0.052	**0.55**	**0.56**	0.21
Cd	**0.70**	**0.87**	0.12	**0.59**	**0.64**	0.26		0.37	0.32	**0.75**	0.23	**0.75**	0.29	0.47	0.25	**0.59**	0.040	0.42	**0.52**	0.27	**0.84**
Cr	0.38	0.27	0.12	**0.76**	**0.82**	-0.32	0.37		-0.16	**0.60**	**0.76**	0.31	**0.92**	0.0036	0.43	-0.050	-0.23	0.036	-0.081	**-0.57**	0.31
Co	0.45	0.34	-0.014	-0.048	0.14	0.45	0.32	-0.16		0.27	-0.039	**0.56**	-0.21	**0.68**	0.16	**0.74**	-0.30	0.059	0.031	**0.67**	0.40
Cu	**0.70**	**0.71**	0.15	**0.74**	**0.74**	0.13	**0.75**	**0.60**	0.27		0.42	**0.69**	**0.59**	0.20	0.44	**0.62**	-0.21	0.093	0.21	0.025	**0.71**
CN-	0.38	0.079	0.47	0.35	**0.69**	-0.25	0.23	**0.76**	-0.039	0.42		0.16	**0.66**	0.14	**0.68**	-0.036	-0.37	-0.28	-0.26	-0.37	0.40
Fe	**0.72**	**0.83**	0.17	0.51	**0.64**	0.42	**0.75**	0.31	**0.56**	**0.69**	0.16		0.29	0.48	0.34	**0.68**	0.15	0.13	0.51	**0.53**	**0.70**
Pb	0.41	0.31	-0.014	**0.78**	**0.78**	-0.24	0.29	**0.92**	-0.21	**0.59**	**0.66**	0.29		-0.0089	0.29	-0.048	-0.072	-0.11	-0.074	**-0.61**	0.13
Mn	**0.59**	0.40	0.11	0.19	0.28	0.42	0.47	0.0036	**0.68**	0.20	0.14	0.48	-0.0089		0.054	0.47	-0.095	0.063	0.14	0.36	0.39
Hg	0.35	0.11	**0.76**	0.068	0.44	0.093	0.25	0.43	0.16	0.44	**0.68**	0.34	0.29	0.054		0.14	**-0.51**	-0.35	-0.18	0.086	**0.58**
Ni	**0.70**	**0.71**	-0.059	0.28	0.35	0.45	**0.59**	-0.050	**0.74**	**0.62**	-0.036	**0.68**	-0.048	0.47	0.14		-0.14	0.059	0.39	**0.65**	**0.56**
Se	-0.19	0.19	-0.14	0.093	-0.056	0.13	0.040	-0.23	-0.30	-0.21	-0.37	0.15	-0.072	-0.095	**-0.51**	-0.14		0.21	**0.55**	0.13	-0.13
Ag	-0.20	0.23	-0.31	0.23	0.11	0.052	0.42	0.036	0.059	0.093	-0.28	0.13	-0.11	0.063	-0.35	0.059	0.21		0.44	-0.0089	0.25
Tl	0.31	**0.71**	-0.088	0.29	0.29	**0.55**	**0.52**	-0.081	0.031	0.21	-0.26	0.51	-0.074	0.14	-0.18	0.39	**0.55**	0.44		0.43	0.29
V	0.30	0.40	0.14	-0.33	-0.17	**0.56**	0.27	**-0.57**	**0.67**	0.025	-0.37	**0.53**	**-0.61**	0.36	0.086	**0.65**	0.13	-0.0089	0.43		0.39
Zn	**0.55**	**0.61**	**0.53**	0.37	**0.53**	0.21	**0.84**	0.31	0.40	**0.71**	0.40	**0.70**	0.13	0.39	**0.58**	**0.56**	-0.13	0.25	0.29	0.39	

Notes:

f_{OC} – Fraction of Total Organic Carbon; HC – Hilliards Creek.

Chemicals: Ag – Silver; Al – Aluminum; As – Arsenic; Ba – Barium; Be – Beryllium; Cd – Cadmium; Cr – Chromium; Co – Cobalt; Cu – Copper; CN- – Cyanide; Fe – Iron; Hg – Mercury; Mn – Manganese; Ni – Nickel; Pb – Lead; Sb – Antimony; Se – Selenium; Tl – Thallium; V – Vanadium; Zn – Zinc.

(a) Correlations performed on 15 primary HC sediment samples combined (no field duplicates). Half of the detection limit was substituted for non-detected samples.

(b) Correlation coefficient (r^2) estimate is based on Spearman rank non-parametric correlation (**bolded** values are significant, $p < 0.05$).

Table A.4b Correlation Between Variables in 2017 Hilliards Creek Soil Samples

Parameter[a,b]	**f_{OC}**	**Al**	**Sb**	**As**	**Ba**	**Be**	**Cd**	**Cr**	**Co**	**Cu**	**CN-**	**Fe**	**Pb**	**Mn**	**Hg**	**Ni**	**Se**	**Ag**	**Tl**	**V**	**Zn**
f_{OC}		0.40	**0.54**	0.14	0.23	0.41	0.20	0.33	0.25	0.32	0.32	0.18	0.18	0.089	0.28	0.47	**0.66**	0.49	-0.18	**0.51**	0.22
Al	0.40		**0.68**	**0.63**	**0.62**	**0.93**	**0.65**	**0.80**	**0.72**	**0.69**	**0.66**	**0.70**	**0.68**	**0.63**	**0.72**	**0.74**	0.45	**0.65**	0.10	**0.82**	**0.66**
Sb	**0.54**	**0.68**		**0.85**	**0.79**	**0.63**	**0.81**	**0.81**	**0.81**	**0.75**	**0.88**	**0.83**	**0.74**	**0.75**	**0.80**	**0.91**	**0.62**	**0.90**	0.31	**0.81**	**0.82**
As	0.14	**0.63**	**0.85**		**0.85**	**0.63**	**0.93**	**0.83**	**0.93**	**0.77**	**0.90**	**0.93**	**0.85**	**0.93**	**0.82**	**0.88**	0.31	**0.76**	0.40	**0.72**	**0.88**
Ba	0.23	**0.62**	**0.79**	**0.85**		**0.59**	**0.83**	**0.91**	**0.83**	**0.92**	**0.88**	**0.71**	**0.89**	**0.84**	**0.89**	**0.78**	0.41	**0.76**	0.21	**0.68**	**0.88**
Be	0.41	**0.93**	**0.63**	**0.63**	**0.59**		**0.64**	**0.80**	**0.76**	**0.57**	**0.62**	**0.69**	**0.68**	**0.60**	**0.58**	**0.74**	0.32	**0.54**	0.047	**0.70**	**0.53**
Cd	0.20	**0.65**	**0.81**	**0.93**	**0.83**	**0.64**		**0.78**	**0.89**	**0.76**	**0.80**	**0.81**	**0.94**	**0.90**	**0.84**	**0.88**	0.38	**0.72**	**0.56**	**0.69**	**0.76**
Cr	0.33	**0.80**	**0.81**	**0.83**	**0.91**	**0.80**	**0.78**		**0.87**	**0.86**	**0.88**	**0.76**	**0.84**	**0.82**	**0.88**	**0.83**	0.41	**0.76**	0.086	**0.72**	**0.84**
Co	0.25	**0.72**	**0.81**	**0.93**	**0.83**	**0.76**	**0.89**	**0.87**		**0.73**	**0.82**	**0.87**	**0.82**	**0.91**	**0.77**	**0.94**	0.24	**0.66**	0.30	**0.68**	**0.83**
Cu	0.32	**0.69**	**0.75**	**0.77**	**0.92**	**0.57**	**0.76**	**0.86**	**0.73**		**0.82**	**0.65**	**0.82**	**0.76**	**0.91**	**0.73**	**0.56**	**0.84**	0.21	**0.77**	**0.90**
CN-	0.32	**0.66**	**0.88**	**0.90**	**0.88**	**0.62**	**0.80**	**0.88**	**0.82**	**0.82**		**0.86**	**0.79**	**0.80**	**0.88**	**0.80**	0.46	**0.83**	0.15	**0.82**	**0.90**
Fe	0.18	**0.70**	**0.83**	**0.93**	**0.71**	**0.69**	**0.81**	**0.76**	**0.87**	**0.65**	**0.86**		**0.71**	**0.84**	**0.70**	**0.81**	0.34	**0.73**	0.30	**0.73**	**0.81**
Pb	0.18	**0.68**	**0.74**	**0.85**	**0.89**	**0.68**	**0.94**	**0.84**	**0.82**	**0.82**	**0.79**	**0.71**		**0.82**	**0.87**	**0.79**	0.39	**0.72**	0.36	**0.70**	**0.74**
Mn	0.089	**0.63**	**0.75**	**0.93**	**0.84**	**0.60**	**0.90**	**0.82**	**0.91**	**0.76**	**0.80**	**0.84**	**0.82**		**0.83**	**0.85**	0.35	**0.61**	0.41	**0.58**	**0.84**
Hg	0.28	**0.72**	**0.80**	**0.82**	**0.89**	**0.58**	**0.84**	**0.88**	**0.77**	**0.91**	**0.88**	**0.70**	**0.87**	**0.83**		**0.79**	**0.52**	**0.81**	0.28	**0.79**	**0.90**
Ni	0.47	**0.74**	**0.91**	**0.88**	**0.78**	**0.74**	**0.88**	**0.83**	**0.94**	**0.73**	**0.80**	**0.81**	**0.79**	**0.85**	**0.79**		0.44	**0.74**	0.38	**0.75**	**0.80**
Se	**0.66**	0.45	**0.62**	0.31	0.41	0.32	0.38	0.41	0.24	**0.56**	0.46	0.34	0.39	0.35	**0.52**	0.44		**0.59**	0.030	**0.57**	0.42
Ag	0.49	**0.65**	**0.90**	**0.76**	**0.76**	**0.54**	**0.72**	**0.76**	**0.66**	**0.84**	**0.83**	**0.73**	**0.72**	**0.61**	**0.81**	**0.74**	**0.59**		0.25	**0.85**	**0.82**
Tl	-0.18	0.10	0.31	0.40	0.21	0.047	**0.56**	0.086	0.30	0.21	0.15	0.30	0.36	0.41	0.28	0.38	0.030	0.25		0.14	0.20
V	**0.51**	**0.82**	**0.81**	**0.72**	**0.68**	**0.70**	**0.69**	**0.72**	**0.68**	**0.77**	**0.82**	**0.73**	**0.70**	**0.58**	**0.79**	**0.75**	**0.57**	**0.85**	0.14		**0.79**
Zn	0.22	**0.66**	**0.82**	**0.88**	**0.88**	**0.53**	**0.76**	**0.84**	**0.83**	**0.90**	**0.90**	**0.81**	**0.74**	**0.84**	**0.90**	**0.80**	0.42	**0.82**	0.20	**0.79**	

Notes:

f_{OC} – Fraction of Total Organic Carbon; HC – Hilliards Creek.

Chemicals: Ag – Silver; Al – Aluminum; As – Arsenic; Ba – Barium; Be – Beryllium; Cd – Cadmium; Cr – Chromium; Co – Cobalt; Cu – Copper; CN- – Cyanide; Fe – Iron; Hg – Mercury; Mn – Manganese; Ni – Nickel; Pb – Lead; Sb – Antimony; Se – Selenium; Tl – Thallium; V – Vanadium; Zn – Zinc.

(a) Correlations performed on 15 primary HC soil samples combined (no field duplicates). Half of the detection limit was substituted for non-detected samples.

(b) Correlation coefficient (r^2) estimate is based on Spearman rank non-parametric correlation (**bolded** values are significant, $p < 0.05$).

Table A.5 Summary of Preliminary Remediation Goals for Benthic Invertebrates in Hilliards Creek

Area of Concern	Endpoint	Sediment PRGs (mg/kg)					
		As	Sample ID[a]	Pb	Sample ID[a]	CN-	Sample ID[a]
Hilliards Creek Background	Survival (NOEC)	20.5	HCBEDD29-SD-AA-AB-0	593	HCBEDD18-SD-AA-AB-0	19.8	HCBEDD20-SD-AA-AB-0
	Sediment Background 95% USL[b]	3.3	NA	40	NA	NA	NA
	Sediment PECs (MacDonald *et al.* , 2000)	33	NA	128	NA	NA	NA
	Sediment PRGs for the Protection of Benthic Invertebrates	**20.5**		**593**		**19.8**	

Notes:

As – Arsenic; BERA – Baseline Ecological Risk Assessment; CN- – Cyanide; LHC – Lower Hilliards Creek; MHC – Middle Hilliards Creek; NA – Not Applicable/Could Not Be Calculated; NOEC – No Observed Effect Concentration; Pb – Lead; PEC – Probable Effect Concentration; PRG – Preliminary Remediation Goal; UHC – Upper Hilliards Creek.

(a) Sample IDs corresponding to the NOEC values are indicated and toxicity test results are shown in Table A.1.

(b) The 95% upper simultaneous limit (95% USL) was calculated to represent the background sediment concentrations in the BERA (Gradient, 2018).

Table A.6 Exposure and Toxicity Parameters for the Sediment or Soil Wildlife Preliminary Remediation Goals

Parameter	Units	Spotted Sandpiper	American Robin	Short-Tailed Shrew	Source
Exposure Medium	mg/kg	Sediment	Soil	Soil	BERA Appendix Table D.2
Hazard Quotient	unitless	1.0	1.0	1.0	Default Assumption
Food Ingestion Rate (per day)	kg/day	0.010	0.0104	0.003	BERA Appendix Table D.2
Body Weight (BW)	kg	0.043	0.079	0.017	BERA Appendix Table D.2
Food Ingestion Rate (per BW-day)	kg/kg-day	0.239	0.131	0.173	Calculated
Sediment Ingestion Proportion	%	10	0	0	BERA Appendix Table D.2
Soil Ingestion Proportion	%	0	10.4	2.4	BERA Appendix Table D.2
Sediment Ingestion Rate (per BW-day)	kg/kg-day	0.0239	0	0	Calculated
Soil Ingestion Rate (per BW-day)	kg/kg-day	0	0.0137	0.0042	Calculated
Food Source	-	100% Benthic Invertebrates	100% Soil Invertebrates	100% Soil Invertebrates	BERA Appendix Table D.2
Biota Bioaccumulation Factor	unitless	Chemical-specific	Chemical-specific	Chemical-specific	Tables A.7-A.8
Biota Bioavailable Fraction (ABS_{food})	%	100	100	100	Default Assumption
Sediment/Soil Bioavailable Fraction (ABS_s)	%	100	100	100	Default Assumption
Area Use Factor	unitless	1.0	1.0	1.0	Default Assumption
Toxicity Reference Value	mg/kg-day	Chemical-specific (BERA)	Chemical-specific (BERA)	Chemical-specific (BERA)	BERA Appendix Table D.3

Notes:

See Sections A.3 and A.4 for details on the preliminary remediation goal (PRG) calculation for wildlife.

Source: BERA – Baseline Ecological Risk Assessment (Gradient, 2018).

Table A.7 Site-specific Bioaccumulation Factors for Benthic Invertebrates

AOC	Upper Hilliards Creek (UHC)												
Station	**(-17)**			**(-19)**			**(-20)**					**(-UH)[a]**		
Media	**Sediment**	**Snails**	**BAF[b]**	**Sediment**	**Crayfish**	**BAF[b]**	**Sediment**	**Snails**	**Snails BAF[b]**	**Crayfish**	**Crayfish BAF[b]**	**Sediment**	**Assorted Benthic Inv.**	**BAF[b]**
Analyte	**mg/kg-dw**	**mg/kg-dw**		**mg/kg-dw**	**mg/kg-dw**		**mg/kg-dw**	**mg/kg-dw**		**mg/kg-dw**		**mg/kg-dw**	**mg/kg-dw**	
ALUMINUM	1530.00 J	63.98	0.04	1760.00 J	145.26	0.08	1180.00 J	183.64	0.16	162.87	0.14	1520.00	282.03	0.19
ANTIMONY	4.90	0.50 U	0.05	2.90	0.86 U	0.15	5.90	2.17	0.37	0.97	0.16	2.80	1.48 U	0.27
ARSENIC	15.80	47.86	3.03	43.00	34.05	0.79	12.80	181.97	14.22	114.35	8.93	13.40	25.78	1.92
BARIUM	89.50	80.60	0.90	117.00	629.31	5.38	63.20	92.32	1.46	308.44	4.88	106.00 J	42.19	0.40
BERYLLIUM	0.21 J	0.25 U	0.60	0.08 J	0.43 U	2.81	0.66 U	0.16 U	0.25	0.41 U	0.63	0.08 J	0.73 U	4.65
CADMIUM	0.43 J	0.25 U	0.29	1.20	0.47	0.40	0.26 J	0.16 U	0.31	0.41 U	0.80	0.49 J	0.73 U	0.75
CHROMIUM	15.70	3.78	0.24	142.00	7.76	0.05	37.70 J	16.53	0.44	15.61	0.41	23.50	22.66	0.96
COBALT	7.70	0.88	0.11	1.30	0.73	0.56	0.61 J	1.25	2.05	0.97	1.59	1.30 J	1.33	1.02
COPPER	24.40	42.57	1.74	22.40	101.72	4.54	9.40	93.49 J	9.95	129.11	13.74	19.40 J	89.84	4.63
CYANIDE	5.10	2.27	0.44	10.90	2.89	0.26	1.80 J	5.34	2.97	9.70	5.39	3.80	7.73	2.04
IRON	5000.00	2871.54	0.57	5260.00	1784.48	0.34	4040.00	14657.76	3.63	2481.01	0.61	3980.00	3953.13	0.99
LEAD	170.00	10.08	0.06	452.00	48.28	0.11	226	166.61	0.74	258.23	1.14	266.00 J	81.25	0.31
MANGANESE	40.90	279.60	6.84	71.20	237.07	3.33	20.9	340.57 J	16.30	367.51	17.58	22.20 J	559.38	25.20
MERCURY	0.67	0.55 U	0.41	0.28	1.03 U	1.85	0.19	0.37 U	0.97	0.89 U	2.33	0.40	1.64 U	2.05
NICKEL	4.10	2.77	0.68	2.30	2.46	1.07	1.10	1.84	1.67	2.45	2.22	2.20 J	4.06	1.85
SELENIUM	0.60 J	1.26 U	1.05	0.42 J	2.16 U	2.57	3.30 U	0.82 U	0.25	2.07 U	0.63	2.70 U	3.67 U	1.36
SILVER	0.05 J	0.25 U	2.80	0.06 J	0.43 U	3.81	0.03 J	0.16 U	2.89	0.41 U	7.38	0.07 J	0.73 U	5.10
THALLIUM	0.61 U	0.25 U	0.41	0.60 U	0.43 U	0.71	0.66 U	0.16 U	0.25	0.41 U	0.63	0.55 U	0.73 U	1.34
VANADIUM	10.30	2.52	0.24	3.10	4.74	1.53	2.70 J	4.34	1.61	4.64	1.72	6.80	9.38	1.38
ZINC	209.00	78.84 J	0.38	252.00	72.41 J	0.29	69.20 J	159.93 J	2.31	105.91 J	1.53	180.00	160.94 J	0.89

Table A.7 Site-specific Bioaccumulation Factors for Benthic Invertebrates

AOC	Middle Hilliards Creek (MHC)														
Station	(-22)					(-23)			(-24)				(-MH)[a]		
Media	Sediment	Snails	Snails BAF[b]	Clams	Clams BAF[b]	Sediment	Clams	BAF[b]	Sediment	Crayfish	Crayfish (duplicate)	BAF[b,c]	Sediment	Assorted Benthic Inv.	BAF[b]
Analyte	mg/kg-dw	mg/kg-dw		mg/kg-dw		mg/kg-dw	mg/kg-dw		mg/kg-dw	mg/kg-dw	mg/kg-dw		mg/kg-dw	mg/kg-dw	
ALUMINUM	3350.00 J	314.00	0.09	90.68	0.03	1690.00	49.32	0.03	6490.00 J	193.85	199.64	0.03	3880.00	461.11	0.12
ANTIMONY	2.00 J	0.48	0.24	0.28 U	0.07	1.50	0.30 U	0.10	1.20 J	0.77 U	0.72 U	0.31	1.30 J	1.46 U	0.56
ARSENIC	68.30 J	146.20	2.14	38.98	0.57	20.70	64.99	3.14	53.20 J	30.38	32.49	0.59	72.20	45.83	0.63
BARIUM	175.00 J	150.20	0.86	185.03	1.06	461.00	197.87	0.43	291.00 J	923.08	790.61	2.94	726.00 J	126.39	0.17
BERYLLIUM	0.32 J	0.20 U	0.31	0.14 U	0.22	0.079 J	0.15 U	0.96	0.24 J	0.38 U	0.36 U	0.78	0.17 J	0.69 U	2.04
CADMIUM	2.70 J	0.20 U	0.04	0.14	0.05	0.39 J	0.18	0.47	0.95 J	0.65	0.61	0.67	1.30 J	0.69 U	0.27
CHROMIUM	38.70 J	12.60	0.33	26.84	0.69	152.00	46.58	0.31	116.00	8.85	10.11	0.08	218	33.33	0.15
COBALT	4.70 J	1.40	0.30	0.96	0.20	0.87	1.26	1.45	1.70 J	0.88	0.90	0.53	1.30	1.11	0.85
COPPER	32.70 J	109.00	3.33	4.66	0.14	20.9	6.54	0.31	21.70 J	134.23	136.46	6.24	46.10 J	37.50	0.81
CYANIDE	0.75 J	1.38	1.84	0.69 U	0.46	24.2	0.84	0.03	9.90 J	3.50	3.29	0.34	33.70	9.72	0.29
IRON	16900.00 J	18820	1.11	2415.25	0.14	4360.00	2390	0.55	12200.00 J	2050	2227.44	0.18	6510.00	5604.17	0.86
LEAD	207.00 J	31.20	0.15	11.30	0.05	812.00	129.07	0.16	989.00 J	100.77	106.50	0.10	1540 J	322.22	0.21
MANGANESE	147.00 J	103.40	0.70	18.79	0.13	13.90	29.98	2.16	91.30 J	212.69	175.81	2.13	34.10 J	85.42	2.50
MERCURY	0.05 J	0.42 U	4.04	0.30 U	2.85	0.19	0.30 U	0.80	0.14 J	0.92 U	0.79 U	3.07	0.16	1.53 U	4.77
NICKEL	9.60 J	6.00	0.63	11.02	1.15	2.30	17.20	7.48	3.50 J	1.46	1.70	0.45	3.40 J	3.82	1.12
SELENIUM	6.80 UJ	1.00 U	0.15	0.72 U	0.11	3.20 U	0.76 U	0.24	5.50 UJ	1.96 U	1.81 U	0.34	0.42 J	3.61 U	4.30
SILVER	1.40 UJ	0.20 U	0.14	0.14 U	0.10	0.05 J	0.15 U	1.62	0.05 J	0.38 U	0.36 U	4.14	0.04 J	0.69 U	7.89
THALLIUM	1.40 UJ	0.20 U	0.14	0.14 U	0.10	0.64 U	0.15 U	0.24	1.10 UJ	0.38 U	0.36 U	0.34	0.85 U	0.69 U	0.82
VANADIUM	11.10 J	4.00	0.36	2.26	0.20	2.10 J	2.89	1.38	8.80 J	4.62	5.05	0.55	5.00	7.64	1.53
ZINC	323.00 J	184.20 J	0.57	12.01 J	0.04	101.00	16.13 J	0.16	114.00 J	126.54 J	121.66 J	1.09	126.00	148.61 J	1.18

Table A.7 Site-specific Bioaccumulation Factors for Benthic Invertebrates

AOC	Lower Hilliards Creek (LHC)																								
Station	(-26)					(-27)					(-28)					(-30)					(-LH)[a]				
Media	Sediment		Clams		BAF[b]	Sediment		Clams		BAF[b]	Sediment		Crayfish		BAF[b]	Sediment		Crayfish		BAF[b]	Sediment		Assorted Benthic Inv.		BAF[b]
Analyte	mg/kg-dw		mg/kg-dw			mg/kg-dw		mg/kg-dw			mg/kg-dw		mg/kg-dw			mg/kg-dw		mg/kg-dw			mg/kg-dw		mg/kg-dw		
ALUMINUM	2330.00		74.08		0.03	987.00		48.72		0.05	1490.00		108.25		0.07	2180.00		191.55		0.09	3690.00		340.77		0.09
ANTIMONY	0.55	J	0.29	U	0.27	0.43	J	0.30	U	0.35	0.43	J	0.69	U	0.80	1.20	J	0.74	U	0.31	0.97	J	1.54	U	0.79
ARSENIC	86.10	J	43.48		0.51	17.20		46.32		2.69	65.70		27.84		0.42	8.20		28.17		3.44	83.00		26.15		0.32
BARIUM	145.00		224.01		1.54	116.00		154.89		1.34	58.60		453.61		7.74	38.60		669.01		17.33	410.00	J	105.38		0.26
BERYLLIUM	0.09	J	0.15	U	0.85	0.09	J	0.15	U	0.81	0.084	J	0.34	U	2.03	0.11	J	0.39	U	1.76	0.22	J	0.77	U	1.75
CADMIUM	0.54	J	0.26		0.49	0.32	J	0.23		0.70	0.28	J	0.96		3.44	0.62	J	0.39	U	0.31	1.20		1.15		0.96
CHROMIUM	132	J	17.72		0.13	85.30	J	37.14		0.44	39.70	J	7.22		0.18	11.00	J	3.87		0.35	164.00		19.23		0.12
COBALT	1.10		1.61		1.46	1.20		1.19		0.99	0.60		1.24		2.06	0.67		0.70		1.05	1.10	J	2.08		1.89
COPPER	65.50		4.98		0.08	13.5		8.72		0.65	11.70		209.62		17.92	18.30		69.01		3.77	93.10	J	58.46		0.63
CYANIDE	2.70		0.70	U	0.13	4.20		1.20		0.29	0.64	U	1.68	U	2.63	0.75	U	1.69	U	2.25	23.90		3.46	U	0.07
IRON	5580.00		1237		0.22	2910.00		1594		0.55	3010.00		1536		0.51	3720.00		2341.55		0.63	5020.00		2515.38		0.50
LEAD	1300.00	J	54.61		0.04	517.00		70.08		0.14	375.00		67.01		0.18	106.00		30.99		0.29	1960.00	J	174.62		0.09
MANGANESE	20.60	J	314.79		15.28	34.70	J	20.00		0.58	12.50	J	192.10		15.37	6.30	J	107.04		16.99	23.80	J	649.23		27.28
MERCURY	0.09	J	0.31	U	1.64	0.048	J	0.32	U	3.29	0.028	J	0.82	U	14.73	0.06	J	0.85	U	7.68	0.13	J	2.15	U	8.28
NICKEL	3.60		8.35		2.32	1.20		14.29		11.90	1.50		2.71		1.81	3.10		2.25		0.73	5.20	J	4.62		0.89
SELENIUM	3.10	U	0.75	U	0.24	2.70	U	0.77	U	0.28	3.50	U	1.72	U	0.49	3.50	U	1.87	U	0.53	0.55	J	3.92	U	3.57
SILVER	0.03	J	0.15	U	2.93	0.55	U	0.15	U	0.27	0.70	U	0.34	U	0.49	0.13	J	0.39	U	1.49	0.41	J	0.77	U	0.94
THALLIUM	0.61	U	0.15	U	0.24	0.55	U	0.15	U	0.27	0.70	U	0.34	U	0.49	0.70	U	0.39	U	0.55	0.93	U	0.77	U	0.83
VANADIUM	2.50	J	2.64		1.05	0.82	J	2.86		3.48	2.00	J	3.78		1.89	7.90		5.28		0.67	4.80		9.23		1.92
ZINC	84.20		15.67	J	0.19	42.20		14.89	J	0.35	42.10		105.84	J	2.51	145.00		127.82	J	0.88	174.00	J	155.38	J	0.89

Table A.7 Site-specific Bioaccumulation Factors for Benthic Invertebrates

AOC	Median BAFs								
Station	Hilliards Creek (HC)						UHC	MHC	LHC
Media / Analyte	Snails (N = 3)	Clams (N = 4)	Crayfish (N = 5)	Assorted Benthic (N = 3)	All Tissues (N = 15)	All Tissues No '-20 (N = 13)	All Tissues (N = 5)	All Tissues (N = 5)	All Tissues (N = 5)
ALUMINUM	0.09	0.03	0.08	0.12	0.08	**0.07**	0.14	0.03	0.07
ANTIMONY	0.24	0.18	0.31	0.56	0.27	**0.27**	0.16	0.24	0.35
ARSENIC	3.03	1.63	0.79	0.63	1.92	**0.79**	3.03	0.63	0.51
BARIUM	0.90	1.20	5.38	0.26	1.34	**1.06**	1.46	0.86	1.54
BERYLLIUM	0.31	0.83	1.76	2.04	0.85	**0.96**	0.63	0.78	1.75
CADMIUM	0.29	0.48	0.67	0.75	0.47	**0.47**	0.40	0.27	0.70
CHROMIUM	0.33	0.37	0.18	0.15	0.31	**0.24**	0.41	0.31	0.18
COBALT	0.30	1.22	1.05	1.02	1.02	**0.99**	1.02	0.53	1.46
COPPER	3.33	0.23	6.24	0.81	3.33	**1.74**	4.63	0.81	0.65
CYANIDE	1.84	0.21	2.25	0.29	0.44	**0.34**	2.04	0.34	0.29
IRON	1.11	0.38	0.51	0.86	0.55	**0.55**	0.61	0.55	0.51
LEAD	0.15	0.10	0.18	0.21	0.15	**0.14**	0.31	0.15	0.14
MANGANESE	6.84	1.37	15.37	25.20	6.84	**3.33**	16.30	2.13	15.37
MERCURY	0.97	2.24	3.07	4.77	2.85	**3.07**	1.85	3.07	7.68
NICKEL	0.68	4.90	1.07	1.12	1.15	**1.12**	1.67	1.12	1.81
SELENIUM	0.25	0.24	0.53	3.57	0.49	**0.49**	1.05	0.24	0.49
SILVER	2.80	0.95	3.81	5.10	2.80	**1.62**	3.81	1.62	0.94
THALLIUM	0.25	0.24	0.55	0.83	0.41	**0.41**	0.63	0.24	0.49
VANADIUM	0.36	1.22	1.53	1.53	1.38	**1.38**	1.53	0.55	1.89
ZINC	0.57	0.17	1.09	0.89	0.88	**0.57**	0.89	0.57	0.88

Notes:

AOC – Area of Concern; BAF – Bioaccumulation Factor; BERA – Baseline Ecological Risk Assessment; dw – Dry Weight; HC – Hilliards Creek; PRG – Preliminary Remediation Goal.

Data Qualifiers:

J – Estimated value.

U – Undetected. The detection limit is presented.

Bolded values (median BAFs for all of HC and using all tissue types) used to derive proposed wildlife PRGs (Table A.9).

(a) To ensure sufficient biomass was available for chemical analysis, composite tissue samples were prepared from tissues collected at multiple stations. Matching sediment samples were created by compositing an equal amount of sediment (10 g) from the same stations used to create the tissue composite sample. See BERA (Gradient, 2018) for further details.

(b) One half the detection limit was used for non-detected samples.

(c) Duplicate tissue samples were averaged.

Table A.8 Site-specific Bioaccumulation Factors for Soil Invertebrates

AOC	Upper Hilliards Creek (UHC)																
Station	HCBESB01	HCBESB01-Dup	HCBESI01	UHC-01	HCBESB02	HCBESI02	UHC-02	HCBESB03	HCBESI03	HCBESI03- Dup	UHC-03	HCBESB04	HCBESI04	UHC-04	HCBESB05	HCBESI05	UHC-05
Media	Soil		EW	BAF[a]	Soil	EW	BAF[a]	Soil	EW		BAF[a]	Soil	EW	BAF[a]	Soil	EW	BAF[a]
Analyte	8/7/2017		8/29/2017		8/2/2017	8/29/2017		8/2/2017	8/29/2017			8/2/2017	8/29/2017		8/2/2017	8/29/2017	
pH					4.9 J			6.4 J				5.9 J			6.0 J		
ALUMINUM	1630 J	1610 J	1104.97 J	0.68	1460 J	243.61 J	0.17	3420	1549.0 J	1344.4 J	0.42	15200 J	1840.8 J	0.12	9040 J	3062.0 J	0.34
ANTIMONY	1.2 J	1.1 J	1.27	1.10	2.3 J	1.05 J	0.46	0.86 J	0.78 J	0.48 J	0.73	11.2 J	2.04	0.18	24.1 J	7.4	0.31
ARSENIC	4.8	4.4	8.29	1.80	3.2 J	2.26	0.70	5.6	8.33	7.22	1.39	32.3 J	30.57	0.95	245 J	141.9	0.58
BARIUM	204	178	723.76	3.79	82.2 J	163.91	1.99	320	365.2	288.9	1.02	582 J	649.7	1.12	534 J	672.9	1.26
BERYLLIUM	0.18 J	0.19 J	0.55 U	1.48	0.13 J	0.75 U	2.89	0.14 J	0.49 U	0.55 U	1.73	0.66 J	0.62 U	0.47	0.5 J	0.2 J	0.47
CADMIUM	0.48 J	0.43 J	5.08	11.17	0.59 J	5.34	9.05	0.47 J	8.82	8.33	18.25	1.6 J	10.19	6.37	2.3 J	15.5	6.74
CHROMIUM	21.5	19.7	39.78	1.93	4.8 J	1.43 J	0.30	12.5	15.20	12.22	1.10	404 J	57.96	0.14	243 J	132.6	0.55
COBALT	1.4	1.2	2.32	1.78	1.4 J	1.58	1.13	2.1	1.47	1.22	0.64	5.3 J	4.14	0.78	10.1 J	5.3	0.52
COPPER	22.7	21.1	38.12	1.74	11.8 J	26.32	2.23	89	50.00	43.89	0.53	122 J	35.67	0.29	96.6 J	63.6	0.66
CYANIDE	1.2	1.3	2.38 J	1.90	0.28 J	3.68 U	6.58	0.45 J	2.35 U	2.67 U	2.79	49.1 J	10.19	0.21	59.8 J	27.1 J	0.45
IRON	4770	5170	3707.18	0.75	5260 J	1165.41	0.22	8280	4166.7	3227.8	0.45	19800 J	4121.0	0.21	60600 J	17441.9	0.29
LEAD	265	241	320.44	1.27	181 J	52.63	0.29	77	53.43	43.33	0.63	1730 J	563.1	0.33	1150 J	1077.5	0.94
MANGANESE	88	70.3	76.80	0.97	14 J	67.67	4.83	132	73.53	62.78	0.52	146 J	107.6	0.74	1560 J	632.6 J	0.41
MERCURY	0.4	0.41	0.99 J	2.46	0.15 J	1.80 U	6.02	0.18	0.48 J	0.56 J	2.86	4.3 J	0.83 J	0.19	0.81 J	1.2 J	1.44
NICKEL	4.1	3.7	11.05	2.83	4.2 J	2.18	0.52	3.6	5.39	4.61	1.39	14.7 J	4.90	0.33	15.5 J	7.4	0.48
SELENIUM	1.2 J	1.3 J	2.54 J	2.03	1 J	1.73 J	1.73	0.75 J	1.37 J	0.89 J	1.51	2.4 J	5.35	2.23	2.1 J	5.3	2.51
SILVER	0.085 J	0.086 J	0.13 J	1.49	0.16 J	0.17 J	1.08	0.14 J	0.22 J	0.18 J	1.42	0.36 J	0.15 J	0.42	0.38 J	0.3 J	0.82
THALLIUM	0.72 U	0.73 U	0.55 U	0.75	1.2 UJ	0.75 U	0.63	0.72 U	0.49 U	0.55 U	0.72	0.48 UJ	0.62 U	1.29	1.6 UJ	0.7 U	0.47
VANADIUM	11.6	10.9	8.29	0.74	13 J	2.56	0.20	12	6.37	4.67	0.46	44.8 J	8.28	0.18	39.2 J	16.3	0.42
ZINC	132	116	201.10	1.62	65.2 J	180.45	2.77	379	229.4	198.33	0.56	824 J	266.9	0.32	870 J	356.6	0.41

Table A.8 Site-specific Bioaccumulation Factors for Soil Invertebrates

AOC	Middle Hillards Creek (MHC)														
Station	HCBESB06	HCBESI06	MHC-06	HCBESB07	HCBESI07	MHC-07	HCBESB08	HCBESI08	MHC-08	HCBESB09	HCBESI09	MHC-09	HCBESB10	HCBESI10	MHC-10
Media	Soil	EW	BAF[a]	Soil	EW	BAF[a]	Soil	EW	BAF[a]	Soil	EW	BAF[a]	Soil	EW	BAF[a]
Analyte	8/22/2017	8/29/2017		8/22/2017	8/29/2017		8/22/2017	8/29/2017		8/22/2017	8/29/2017		8/21/2017	8/29/2017	
pH	6.4 J			6.1 J			5.6 J			6.4 J			3.6 J		
ALUMINUM	7910 J	3209.3 J	0.41	9840 J	1435.7 J	0.15	8700 J	511.3 J	0.06	8040 J	2408 J	0.30	1450	200.0 J	0.14
ANTIMONY	17.3 J	7.7	0.44	15.5 J	2.0	0.13	3.4 J	1.27 J	0.37	12.4 J	5.12	0.41	1.5 J	0.6 J	0.37
ARSENIC	296 J	197.7	0.67	132 J	70.0	0.53	80.9 J	42.96	0.53	276 J	239.2	0.87	1.2 J	1.4	1.20
BARIUM	2280 J	1899.2	0.83	563 J	1350	2.40	316 J	518.3	1.64	3420 J	2896	0.85	36.7 J	99.3	2.71
BERYLLIUM	0.39 J	0.3 J	0.74	0.88 J	0.24 J	0.27	0.72 J	0.70 U	0.49	0.59 J	0.296 J	0.50	0.069 J	0.7 U	4.95
CADMIUM	2.5 J	30.2	12.09	2 J	16.43	8.21	1.3 J	7.75	5.96	3.3 J	18.4	5.58	0.2 J	6.9	34.53
CHROMIUM	358 J	149.6	0.42	1030 J	61.43	0.06	160 J	5.70	0.04	708 J	212.8	0.30	3 J	2.1	0.70
COBALT	10.8 J	5.7	0.53	14.6 J	7.86	0.54	2.7 J	4.51	1.67	13.3 J	7.76	0.58	0.32 J	1.2	3.60
COPPER	118 J	85.3	0.72	90.1 J	45.0	0.50	44.5 J	26.76	0.60	115 J	68.8	0.60	9.9 J	25.9	2.62
CYANIDE	51.2 J	33.3	0.65	22.5 J	7.0	0.31	10.4 J	3.38 U	0.16	105 J	54.4	0.52	0.17 J	3.5 U	10.16
IRON	48300 J	21627.9	0.45	34400 J	6592.9	0.19	30100 J	1605.6	0.05	50700 J	14720	0.29	2410	553.2	0.23
LEAD	2740 J	2015.5	0.74	1650 J	246.4	0.15	1290 J	290.8	0.23	4710 J	2240	0.48	57.7	41.0	0.71
MANGANESE	1690 J	969	0.57	865 J	349.3	0.40	81.7 J	103.5	1.27	2460 J	944	0.38	32.4	133.1	4.11
MERCURY	1.1 J	0.8 J	0.70	0.54 J	0.35 J	0.65	0.18 J	0.34 J	1.88	1.2 J	0.8 J	0.67	0.099 J	1.5 U	7.63
NICKEL	15.3 J	11.6	0.76	21.4 J	5.43	0.25	9.8 J	3.66	0.37	15.1 J	11.2	0.74	3.6 J	2.9	0.80
SELENIUM	2.1 J	6.4	3.06	1.8 J	3.64 J	2.02	2 J	4.44	2.22	1.9 J	5.28	2.78	4.4 U	3.5	1.57
SILVER	0.49 J	0.7 J	1.38	0.19 J	0.15 J	0.79	0.18 J	0.32 J	1.76	0.3 J	0.424 J	1.41	0.11 J	0.2 J	1.50
THALLIUM	0.94 UJ	0.8 U	0.82	0.48 UJ	0.79 U	1.64	0.47 UJ	0.70 U	1.50	1.1 UJ	0.8 U	0.73	0.87 U	0.7 U	0.79
VANADIUM	37.7 J	17.8	0.47	23.2 J	5.29	0.23	38.2 J	3.31	0.09	20 J	10.4	0.52	5.5	1.0	0.18
ZINC	878 J	790.7	0.90	602 J	283.6	0.47	171 J	252.1	1.47	812 J	556	0.68	33.2	202.9	6.11

Table A.8 Site-specific Bioaccumulation Factors for Soil Invertebrates

AOC	Lower Hilliards Creek (LHC)															Median BAFs			
Station	HCBESB11	HCBESI11	LHC-11	HCBESB12	HCBESI12	LHC-12	HCBESB13	HCBESI13	LHC-13	HCBESB14	HCBESI14	LHC-14	HCBESB15	HCBESI15	LHC-15	UHC	MHC	LHC	HC
Media	Soil	EW	BAF[a]	Soil	EW	BAF[a]	Soil	EW	BAF[a]	Soil	EW	BAF[a]	Soil	EW	BAF[a]	(N = 5)	(N = 5)	(N = 5)	(N = 15)
Analyte	8/21/2017	8/29/2017		8/24/2017	8/29/2017		8/24/2017	8/29/2017		8/23/2017	8/29/2017		8/21/2017	8/29/2017					
pH	6.1 J			6.2 J			5.8 J			5.3 J			5.1 J						
ALUMINUM	5840	683.9 J	0.12	12300 J	3506.4 J	0.29	10700 J	1595.9 J	0.15	3590	1012.3 J	0.28	3640	1487.2 J	0.41	0.34	0.15	0.28	**0.28**
ANTIMONY	2.9	0.66 J	0.23	3.9 J	1.4	0.36	3.4 J	0.89 J	0.26	1.4 J	0.80 J	0.57	0.61 J	0.45 J	0.74	0.46	0.37	0.36	**0.37**
ARSENIC	106 J	60.92	0.57	198 J	210.9	1.07	92.9 J	62.33	0.67	3	2.41	0.80	1.8 J	2.91	1.61	0.95	0.67	0.80	**0.80**
BARIUM	546	288.5	0.53	513 J	852.6	1.66	545 J	99.32	0.18	25.3	54.32	2.15	15.1	56.41	3.74	1.26	1.64	1.66	**1.64**
BERYLLIUM	0.43 J	1.15 U	1.34	0.75 J	0.3 J	0.40	0.86 J	0.68 U	0.40	0.21 J	0.62 U	1.47	0.24 J	0.85 U	1.78	1.48	0.50	1.34	**0.74**
CADMIUM	2.2	58.62	26.65	2.9 J	25.6	8.84	2.4 J	30.14	12.56	0.19 J	8.02	42.24	0.18 J	6.50	36.09	9.05	8.21	26.65	**11.17**
CHROMIUM	184 J	27.59	0.15	219 J	42.3	0.19	285 J	36.99	0.13	10.4	12.96	1.25	6.9 J	10.26	1.49	0.55	0.30	0.19	**0.30**
COBALT	7.2	3.56	0.49	14.3 J	7.7	0.54	6.4 J	4.11	0.64	0.49 J	1.79	3.65	0.73	0.94	1.29	0.78	0.58	0.64	**0.64**
COPPER	55.6	37.93	0.68	75.6 J	45.5	0.60	115 J	38.36	0.33	6.7	23.46	3.50	7.8 J	31.62	4.05	0.66	0.60	0.68	**0.66**
CYANIDE	9.7	7.70	0.79	7.9 J	2.9 J	0.37	5.1 J	1.71 J	0.34	0.27 J	2.96 U	5.49	0.23 J	4.19 U	9.10	1.90	0.52	0.79	**0.65**
IRON	24300	3137.9	0.13	40000 J	9679.5	0.24	22000 J	4363.0	0.20	5300	1487.7	0.28	14700	5205.1	0.35	0.29	0.23	0.24	**0.24**
LEAD	1720	926.4	0.54	1760 J	750.0	0.43	2630 J	1349.3	0.51	76.1	193.8	2.55	17	44.44	2.61	0.63	0.48	0.54	**0.54**
MANGANESE	582	87.36	0.15	1740 J	320.5	0.18	407 J	134.9	0.33	15.2	100	6.58	18.3	42.74	2.34	0.74	0.57	0.33	**0.57**
MERCURY	0.27	1.15 J	4.26	0.59 J	0.5 J	0.83	0.55 J	1.44 U	1.31	0.1 J	0.32 J	3.21	0.033 J	1.79 U	27.20	2.46	0.70	3.21	**1.88**
NICKEL	10.7 J	4.48	0.42	17.2 J	7.1	0.41	15 J	6.10	0.41	3	7.41	2.47	2.4 J	5.38	2.24	0.52	0.74	0.42	**0.52**
SELENIUM	0.99 J	12.64	12.77	1.8 J	12.2	6.77	2 J	12.33	6.16	0.39 J	1.67 J	4.27	2.4 U	1.37 J	1.14	2.03	2.22	6.16	**2.23**
SILVER	0.12 J	1.49	12.45	0.16 J	0.3 J	1.80	0.24 J	0.40 J	1.68	0.14 J	0.43 J	3.04	0.065 J	0.45 J	6.97	1.08	1.41	3.04	**1.49**
THALLIUM	0.68 J	1.15 U	0.85	1.5 UJ	0.6 U	0.43	1.6 UJ	0.68 U	0.43	0.85 U	0.62 U	0.73	0.48 U	0.85 U	1.78	0.72	0.82	0.73	**0.75**
VANADIUM	17.8	2.87	0.16	32.8 J	10.3	0.31	30 J	4.66	0.16	11	3.40	0.31	9.9	4.70	0.47	0.42	0.23	0.31	**0.31**
ZINC	378	506.9	1.34	498 J	387.8	0.78	359 J	456.2	1.27	39.6	249.4	6.30	40.2	197.4	4.91	0.56	0.90	1.34	**1.27**

Notes:

AOC – Area of Concern; BAF – Bioaccumulation Factor; dw – Dry Weight; EW – Earthworm; ND – Not Detected; PRG – Preliminary Remediation Goal.

Data Qualifiers:

J – Estimated value.

U – Undetected. The detection limit is presented.

Bolded values (median BAFs for all of HC) used to derive proposed wildlife PRGs (Table A.9)

(a) One half the detection limit used for non-detected samples.

Table A.9 Summary of Wildlife Preliminary Remediation Goals

Receptor	COPC	Media	TRV (mg/kg-day)	TRV Source	UHC Site-specific Tissue Bioaccumulation Factors		Eco. PRG (HQ = 1)
Spotted Sandpiper	Aluminum	Sediment	1100	LOAEL (BERA Table D.3)	0.14	Median BAF from all UHC Samples (Table A.7)	19335
	Antimony	Sediment	NC	LOAEL (BERA Table D.3)	0.16	Median BAF from all UHC Samples (Table A.7)	na
	Arsenic	Sediment	3.6	LOAEL (BERA Table D.3)	3.0	Median BAF from all UHC Samples (Table A.7)	4.7
	Barium	Sediment	42	LOAEL (BERA Table D.3)	1.5	Median BAF from all UHC Samples (Table A.7)	112
	Cadmium	Sediment	2.4	LOAEL (BERA Table D.3)	0.40	Median BAF from all UHC Samples (Table A.7)	20
	Chromium	Sediment	2.8	LOAEL (BERA Table D.3)	0.41	Median BAF from all UHC Samples (Table A.7)	23
	Copper	Sediment	12	LOAEL (BERA Table D.3)	4.6	Median BAF from all UHC Samples (Table A.7)	11
	Cyanide	Sediment	0.40	LOAEL (BERA Table D.3)	2.0	Median BAF from all UHC Samples (Table A.7)	0.78
	Lead	Sediment	9.9	ED_{20} (BERA Table D.3)	0.31	Median BAF from all UHC Samples (Table A.7)	102
	Manganese	Sediment	348	LOAEL (BERA Table D.3)	16	Median BAF from all UHC Samples (Table A.7)	89
	Selenium	Sediment	0.58	LOAEL (BERA Table D.3)	1.0	Median BAF from all UHC Samples (Table A.7)	2.1
	Thallium	Sediment	3.5	LOAEL (BERA Table D.3)	0.63	Median BAF from all UHC Samples (Table A.7)	20
	Vanadium	Sediment	0.69	LOAEL (BERA Table D.3)	1.5	Median BAF from all UHC Samples (Table A.7)	1.8
American Robin	Aluminum	Soil	1100	LOAEL (BERA Table D.3)	0.34	Median BAF from all UHC Samples (Table A.8)	18924
	Antimony	Soil	NC	LOAEL (BERA Table D.3)	0.46	Median BAF from all UHC Samples (Table A.8)	na
	Arsenic	Soil	3.6	LOAEL (BERA Table D.3)	0.95	Median BAF from all UHC Samples (Table A.8)	26
	Barium	Soil	42	LOAEL (BERA Table D.3)	1.3	Median BAF from all UHC Samples (Table A.8)	233
	Cadmium	Soil	2.4	LOAEL (BERA Table D.3)	9.0	Median BAF from all UHC Samples (Table A.8)	2.0
	Chromium	Soil	2.8	LOAEL (BERA Table D.3)	0.55	Median BAF from all UHC Samples (Table A.8)	33
	Copper	Soil	12	LOAEL (BERA Table D.3)	0.66	Median BAF from all UHC Samples (Table A.8)	121
	Cyanide	Soil	0.40	LOAEL (BERA Table D.3)	1.9	Median BAF from all UHC Samples (Table A.8)	1.5
	Lead	Soil	9.9	ED_{20} (BERA Table D.3)	0.63	Median BAF from all UHC Samples (Table A.8)	103
	Manganese	Soil	348	LOAEL (BERA Table D.3)	0.74	Median BAF from all UHC Samples (Table A.8)	3150
	Selenium	Soil	0.58	LOAEL (BERA Table D.3)	2.0	Median BAF from all UHC Samples (Table A.8)	2.1
	Thallium	Soil	3.5	LOAEL (BERA Table D.3)	0.72	Median BAF from all UHC Samples (Table A.8)	32
	Vanadium	Soil	0.69	LOAEL (BERA Table D.3)	0.42	Median BAF from all UHC Samples (Table A.8)	10
Short-Tailed Shrew	Aluminum	Soil	100	LOAEL (BERA Table D.3)	0.34	Median BAF from all UHC Samples (Table A.8)	1589
	Antimony	Soil	0.59	LOAEL (BERA Table D.3)	0.46	Median BAF from all UHC Samples (Table A.8)	7.1
	Arsenic	Soil	1.7	LOAEL (BERA Table D.3)	0.95	Median BAF from all UHC Samples (Table A.8)	9.9
	Barium	Soil	121	LOAEL (BERA Table D.3)	1.3	Median BAF from all UHC Samples (Table A.8)	543
	Cadmium	Soil	7.7	LOAEL (BERA Table D.3)	9.0	Median BAF from all UHC Samples (Table A.8)	4.9
	Chromium	Soil	2.8	LOAEL (BERA Table D.3)	0.55	Median BAF from all UHC Samples (Table A.8)	29
	Copper	Soil	9.3	LOAEL (BERA Table D.3)	0.66	Median BAF from all UHC Samples (Table A.8)	79
	Cyanide	Soil	687	LOAEL (BERA Table D.3)	1.9	Median BAF from all UHC Samples (Table A.8)	2058
	Lead	Soil	8.9	LOAEL (BERA Table D.3)	0.63	Median BAF from all UHC Samples (Table A.8)	79
	Manganese	Soil	65	LOAEL (BERA Table D.3)	0.74	Median BAF from all UHC Samples (Table A.8)	492
	Selenium	Soil	0.22	LOAEL (BERA Table D.3)	2.0	Median BAF from all UHC Samples (Table A.8)	0.60
	Thallium	Soil	0.071	LOAEL (BERA Table D.3)	0.72	Median BAF from all UHC Samples (Table A.8)	0.55
	Vanadium	Soil	8.3	LOAEL (BERA Table D.3)	0.42	Median BAF from all UHC Samples (Table A.8)	109

Notes:
BAF – Bioaccumulation Factor; COPC – Chemical of Potential Concern; ED_{20} – 20% Effective Dose; HC – Hilliards Creek; HQ – Hazard Quotient; LOAEL – Lowest Observed Adverse Effect Level; na – Not Analyzed; PRG –
See Tables A.6, A.7, and A.8 for exposure parameters, and Sections A.3 and A.4 for discussion of the PRG methodology.
Source: BERA – Baseline Ecological Risk Assessment (Gradient, 2018).
Bolded values proposed as wildlife PRGs.

Table A.9 Summary of Wildlife Preliminary Remediation Goals

Receptor	COPC	Media	TRV (mg/kg-day)	TRV Source	HC Site-specific Tissue Bioaccumulation Factors		Eco. PRG (HQ = 1)
Spotted Sandpiper	Aluminum	Sediment	1100	LOAEL (BERA Table D.3)	0.083	Median BAF from all HC Samples (Table A.7)	25213
	Antimony	Sediment	NC	LOAEL (BERA Table D.3)	0.27	Median BAF from all HC Samples (Table A.7)	na
	Arsenic	Sediment	3.6	LOAEL (BERA Table D.3)	1.9	Median BAF from all HC Samples (Table A.7)	7.3
	Barium	Sediment	42	LOAEL (BERA Table D.3)	1.3	Median BAF from all HC Samples (Table A.7)	121
	Cadmium	Sediment	2.4	LOAEL (BERA Table D.3)	0.47	Median BAF from all HC Samples (Table A.7)	17
	Chromium	Sediment	2.8	LOAEL (BERA Table D.3)	0.31	Median BAF from all HC Samples (Table A.7)	29
	Copper	Sediment	12	LOAEL (BERA Table D.3)	3.3	Median BAF from all HC Samples (Table A.7)	15
	Cyanide	Sediment	0.40	LOAEL (BERA Table D.3)	0.44	Median BAF from all HC Samples (Table A.7)	3.1
	Lead	Sediment	9.9	ED_{20} (BERA Table D.3)	0.15	Median BAF from all HC Samples (Table A.7)	165
	Manganese	Sediment	348	LOAEL (BERA Table D.3)	6.8	Median BAF from all HC Samples (Table A.7)	210
	Selenium	Sediment	0.58	LOAEL (BERA Table D.3)	0.49	Median BAF from all HC Samples (Table A.7)	4.1
	Thallium	Sediment	3.5	LOAEL (BERA Table D.3)	0.41	Median BAF from all HC Samples (Table A.7)	29
	Vanadium	Sediment	0.69	LOAEL (BERA Table D.3)	1.4	Median BAF from all HC Samples (Table A.7)	1.9
American Robin	Aluminum	Soil	1100	LOAEL (BERA Table D.3)	0.28	Median BAF from all HC Samples (Table A.8)	21705
	Antimony	Soil	NC	LOAEL (BERA Table D.3)	0.37	Median BAF from all HC Samples (Table A.8)	na
	Arsenic	Soil	3.6	LOAEL (BERA Table D.3)	0.80	Median BAF from all HC Samples (Table A.8)	30
	Barium	Soil	42	LOAEL (BERA Table D.3)	1.6	Median BAF from all HC Samples (Table A.8)	182
	Cadmium	Soil	2.4	LOAEL (BERA Table D.3)	11	Median BAF from all HC Samples (Table A.8)	1.6
	Chromium	Soil	2.8	LOAEL (BERA Table D.3)	0.30	Median BAF from all HC Samples (Table A.8)	52
	Copper	Soil	12	LOAEL (BERA Table D.3)	0.66	Median BAF from all HC Samples (Table A.8)	121
	Cyanide	Soil	0.40	LOAEL (BERA Table D.3)	0.65	Median BAF from all HC Samples (Table A.8)	4.0
	Lead	Soil	9.9	ED_{20} (BERA Table D.3)	0.54	Median BAF from all HC Samples (Table A.8)	117
	Manganese	Soil	348	LOAEL (BERA Table D.3)	0.57	Median BAF from all HC Samples (Table A.8)	3913
	Selenium	Soil	0.58	LOAEL (BERA Table D.3)	2.2	Median BAF from all HC Samples (Table A.8)	1.9
	Thallium	Soil	3.5	LOAEL (BERA Table D.3)	0.75	Median BAF from all HC Samples (Table A.8)	31
	Vanadium	Soil	0.69	LOAEL (BERA Table D.3)	0.31	Median BAF from all HC Samples (Table A.8)	13
Short-Tailed Shrew	Aluminum	Soil	100	LOAEL (BERA Table D.3)	0.28	Median BAF from all HC Samples (Table A.8)	1884
	Antimony	Soil	0.59	LOAEL (BERA Table D.3)	0.37	Median BAF from all HC Samples (Table A.8)	8.5
	Arsenic	Soil	1.7	LOAEL (BERA Table D.3)	0.80	Median BAF from all HC Samples (Table A.8)	12
	Barium	Soil	121	LOAEL (BERA Table D.3)	1.6	Median BAF from all HC Samples (Table A.8)	419
	Cadmium	Soil	7.7	LOAEL (BERA Table D.3)	11	Median BAF from all HC Samples (Table A.8)	4.0
	Chromium	Soil	2.8	LOAEL (BERA Table D.3)	0.30	Median BAF from all HC Samples (Table A.8)	50
	Copper	Soil	9.3	LOAEL (BERA Table D.3)	0.66	Median BAF from all HC Samples (Table A.8)	79
	Cyanide	Soil	687	LOAEL (BERA Table D.3)	0.65	Median BAF from all HC Samples (Table A.8)	5866
	Lead	Soil	8.9	LOAEL (BERA Table D.3)	0.54	Median BAF from all HC Samples (Table A.8)	91
	Manganese	Soil	65	LOAEL (BERA Table D.3)	0.57	Median BAF from all HC Samples (Table A.8)	627
	Selenium	Soil	0.22	LOAEL (BERA Table D.3)	2.2	Median BAF from all HC Samples (Table A.8)	0.55
	Thallium	Soil	0.071	LOAEL (BERA Table D.3)	0.75	Median BAF from all HC Samples (Table A.8)	0.53
	Vanadium	Soil	8.3	LOAEL (BERA Table D.3)	0.31	Median BAF from all HC Samples (Table A.8)	144

Notes:
BAF – Bioaccumulation Factor; COPC – Chemical of Potential Concern; ED_{20} – 20% Effective Dose; HC – Hilliards Creek; HQ – Hazard Quotient; LOAEL – Lowest Observed Adverse Effect Level; na – Not Analyzed; PRG –
See Tables A.6, A.7, and A.8 for exposure parameters, and Sections A.3 and A.4 for discussion of the PRG methodology.
Source: BERA – Baseline Ecological Risk Assessment (Gradient, 2018).
Bolded values proposed as wildlife PRGs.

Table A.9 Summary of Wildlife Preliminary Remediation Goals

Receptor	COPC	Media	TRV (mg/kg-day)	TRV Source	HC Site-specific Tissue Bioaccumulation Factors (No '-20)		Eco. PRG (HQ = 1)
Spotted Sandpiper	Aluminum	Sediment	1100	LOAEL (BERA Table D.3)	0.073	Median BAF from all HC Samples, except '-20 (Table A.7)	**26656**
	Antimony	Sediment	NC	LOAEL (BERA Table D.3)	0.27	Median BAF from all HC Samples, except '-20 (Table A.7)	**na**
	Arsenic	Sediment	3.6	LOAEL (BERA Table D.3)	0.79	Median BAF from all HC Samples, except '-20 (Table A.7)	**17**
	Barium	Sediment	42	LOAEL (BERA Table D.3)	1.1	Median BAF from all HC Samples, except '-20 (Table A.7)	**151**
	Cadmium	Sediment	2.4	LOAEL (BERA Table D.3)	0.47	Median BAF from all HC Samples, except '-20 (Table A.7)	**17**
	Chromium	Sediment	2.8	LOAEL (BERA Table D.3)	0.24	Median BAF from all HC Samples, except '-20 (Table A.7)	**34**
	Copper	Sediment	12	LOAEL (BERA Table D.3)	1.7	Median BAF from all HC Samples, except '-20 (Table A.7)	**27**
	Cyanide	Sediment	0.40	LOAEL (BERA Table D.3)	0.34	Median BAF from all HC Samples, except '-20 (Table A.7)	**3.8**
	Lead	Sediment	9.9	ED_{20} (BERA Table D.3)	0.14	Median BAF from all HC Samples, except '-20 (Table A.7)	**176**
	Manganese	Sediment	348	LOAEL (BERA Table D.3)	3.3	Median BAF from all HC Samples, except '-20 (Table A.7)	**425**
	Selenium	Sediment	0.58	LOAEL (BERA Table D.3)	0.49	Median BAF from all HC Samples, except '-20 (Table A.7)	**4.1**
	Thallium	Sediment	3.5	LOAEL (BERA Table D.3)	0.41	Median BAF from all HC Samples, except '-20 (Table A.7)	**29**
	Vanadium	Sediment	0.69	LOAEL (BERA Table D.3)	1.4	Median BAF from all HC Samples, except '-20 (Table A.7)	**1.9**
American Robin	Aluminum	Soil	1100	LOAEL (BERA Table D.3)	0.28	Median BAF from all HC Samples (Table A.8)	**21705**
	Antimony	Soil	NC	LOAEL (BERA Table D.3)	0.37	Median BAF from all HC Samples (Table A.8)	**na**
	Arsenic	Soil	3.6	LOAEL (BERA Table D.3)	0.80	Median BAF from all HC Samples (Table A.8)	**30**
	Barium	Soil	42	LOAEL (BERA Table D.3)	1.6	Median BAF from all HC Samples (Table A.8)	**182**
	Cadmium	Soil	2.4	LOAEL (BERA Table D.3)	11	Median BAF from all HC Samples (Table A.8)	**1.6**
	Chromium	Soil	2.8	LOAEL (BERA Table D.3)	0.30	Median BAF from all HC Samples (Table A.8)	**52**
	Copper	Soil	12	LOAEL (BERA Table D.3)	0.66	Median BAF from all HC Samples (Table A.8)	**121**
	Cyanide	Soil	0.40	LOAEL (BERA Table D.3)	0.65	Median BAF from all HC Samples (Table A.8)	**4.0**
	Lead	Soil	9.9	ED_{20} (BERA Table D.3)	0.54	Median BAF from all HC Samples (Table A.8)	**117**
	Manganese	Soil	348	LOAEL (BERA Table D.3)	0.57	Median BAF from all HC Samples (Table A.8)	**3913**
	Selenium	Soil	0.58	LOAEL (BERA Table D.3)	2.2	Median BAF from all HC Samples (Table A.8)	**1.9**
	Thallium	Soil	3.5	LOAEL (BERA Table D.3)	0.75	Median BAF from all HC Samples (Table A.8)	**31**
	Vanadium	Soil	0.69	LOAEL (BERA Table D.3)	0.31	Median BAF from all HC Samples (Table A.8)	**13**
Short-Tailed Shrew	Aluminum	Soil	100	LOAEL (BERA Table D.3)	0.28	Median BAF from all HC Samples (Table A.8)	**1884**
	Antimony	Soil	0.59	LOAEL (BERA Table D.3)	0.37	Median BAF from all HC Samples (Table A.8)	**8.5**
	Arsenic	Soil	1.7	LOAEL (BERA Table D.3)	0.80	Median BAF from all HC Samples (Table A.8)	**12**
	Barium	Soil	121	LOAEL (BERA Table D.3)	1.6	Median BAF from all HC Samples (Table A.8)	**419**
	Cadmium	Soil	7.7	LOAEL (BERA Table D.3)	11	Median BAF from all HC Samples (Table A.8)	**4.0**
	Chromium	Soil	2.8	LOAEL (BERA Table D.3)	0.30	Median BAF from all HC Samples (Table A.8)	**50**
	Copper	Soil	9.3	LOAEL (BERA Table D.3)	0.66	Median BAF from all HC Samples (Table A.8)	**79**
	Cyanide	Soil	687	LOAEL (BERA Table D.3)	0.65	Median BAF from all HC Samples (Table A.8)	**5866**
	Lead	Soil	8.9	LOAEL (BERA Table D.3)	0.54	Median BAF from all HC Samples (Table A.8)	**91**
	Manganese	Soil	65	LOAEL (BERA Table D.3)	0.57	Median BAF from all HC Samples (Table A.8)	**627**
	Selenium	Soil	0.22	LOAEL (BERA Table D.3)	2.2	Median BAF from all HC Samples (Table A.8)	**0.55**
	Thallium	Soil	0.071	LOAEL (BERA Table D.3)	0.75	Median BAF from all HC Samples (Table A.8)	**0.53**
	Vanadium	Soil	8.3	LOAEL (BERA Table D.3)	0.31	Median BAF from all HC Samples (Table A.8)	**144**

Notes:
BAF – Bioaccumulation Factor; COPC – Chemical of Potential Concern; ED_{20} – 20% Effective Dose; HC – Hilliards Creek; HQ – Hazard Quotient; LOAEL – Lowest Observed Adverse Effect Level; na – Not Analyzed; PRG –
See Tables A.6, A.7, and A.8 for exposure parameters, and Sections A.3 and A.4 for discussion of the PRG methodology.
Source: BERA – Baseline Ecological Risk Assessment (Gradient, 2018).
Bolded values proposed as wildlife PRGs.

Table A.10 Ecological Preliminary Remediation Goals for Sediments and Soils

COPC	Benthic Invertebrate PRG[a]	Spotted Sandpiper PRG[b]	Background Sediment 95% USL[c]	Final Sediment Eco. PRGs	American Robin PRG[b]	Short-Tailed Shrew PRG[b]	Background Soil 95% USL[c]	Final Soil Eco. PRGs
Arsenic	20.5	17	3.3	**17**	30	12	17	**17**
Lead	593	176	40	**176**	117	91	213	**213**
Cyanide	19.8	3.8	NA	**3.8**	4.0	5866	58	**58**

Notes:

95% UCL – 95% Upper Confidence Level; 95% USL – 95% Upper Simultaneous Limit; BERA – Baseline Ecological Risk Assessment; COPC – Chemical of Potential Concern; PRG – Preliminary Remediation Goal.

Units are mg/kg-day.

(a) See Table A.5. To be met within a small areal extent, because benthic invertebrates are sessile.

(b) See Table A.9. To be met on average (*i.e.* , 95% UCL) over the entire exposure area. The wildlife PRGs were derived using the median BAFs from all HC samples as shown in Table A.7 (benthic invertebrates; excluding outlier sample -20) and Table A.8 (soil invertebrates).

(c) See BERA Appendix Tables B.9 (soil) and B.10 (sediment) for background summary statistics (Gradient, 2018).

Figures

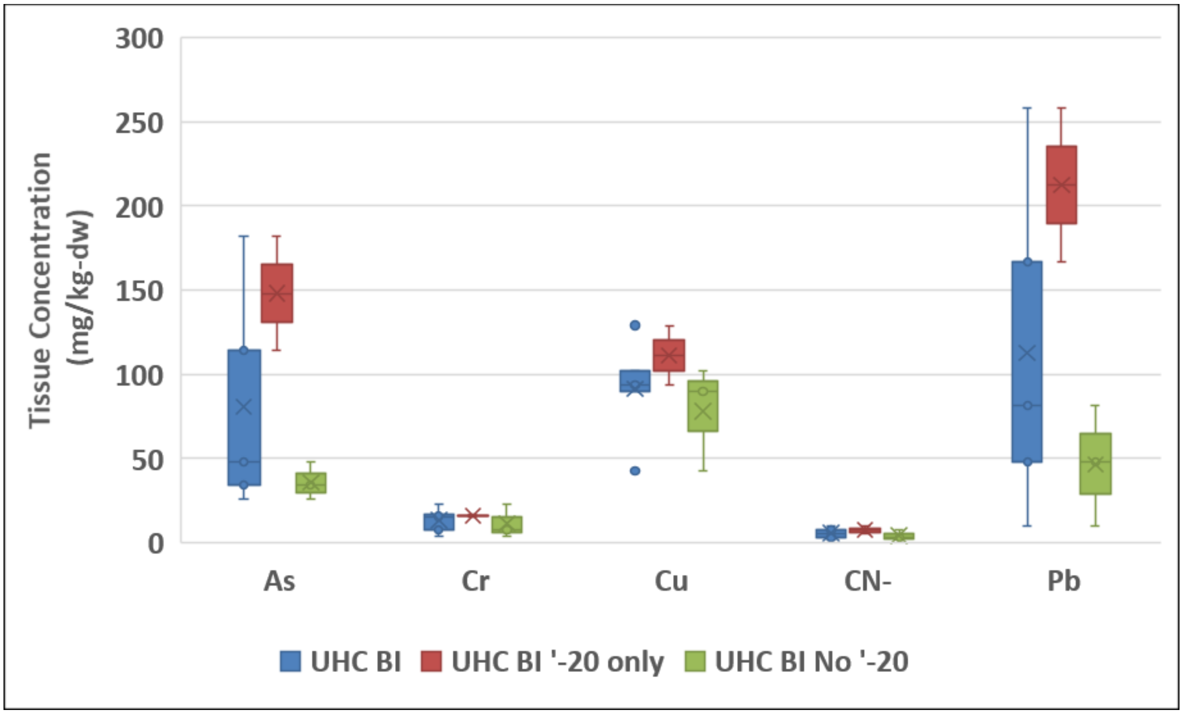

Figure 1 Benthic Invertebrate Tissue Concentrations in UHC. As – Arsenic; BI – Benthic Invertebrate; CN- – Cyanide; Cr – Chromium; Cu – Copper; dw – Dry Weight; Pb – Lead; UHC – Upper Hilliards Creek.

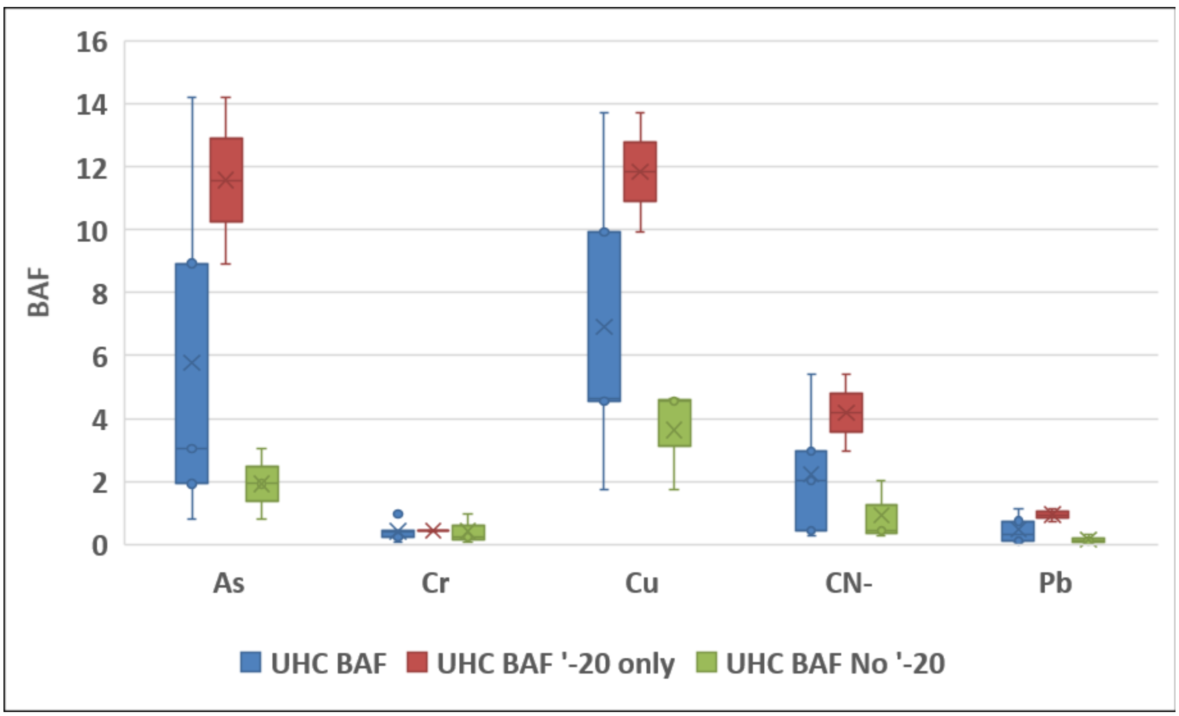

Figure 2 Bioaccumulation Factors in UHC. As – Arsenic; BAF – Bioaccumulation Factor; CN- – Cyanide; Cr – Chromium; Cu – Copper; Pb – Lead; UHC –Upper Hilliards Creek.

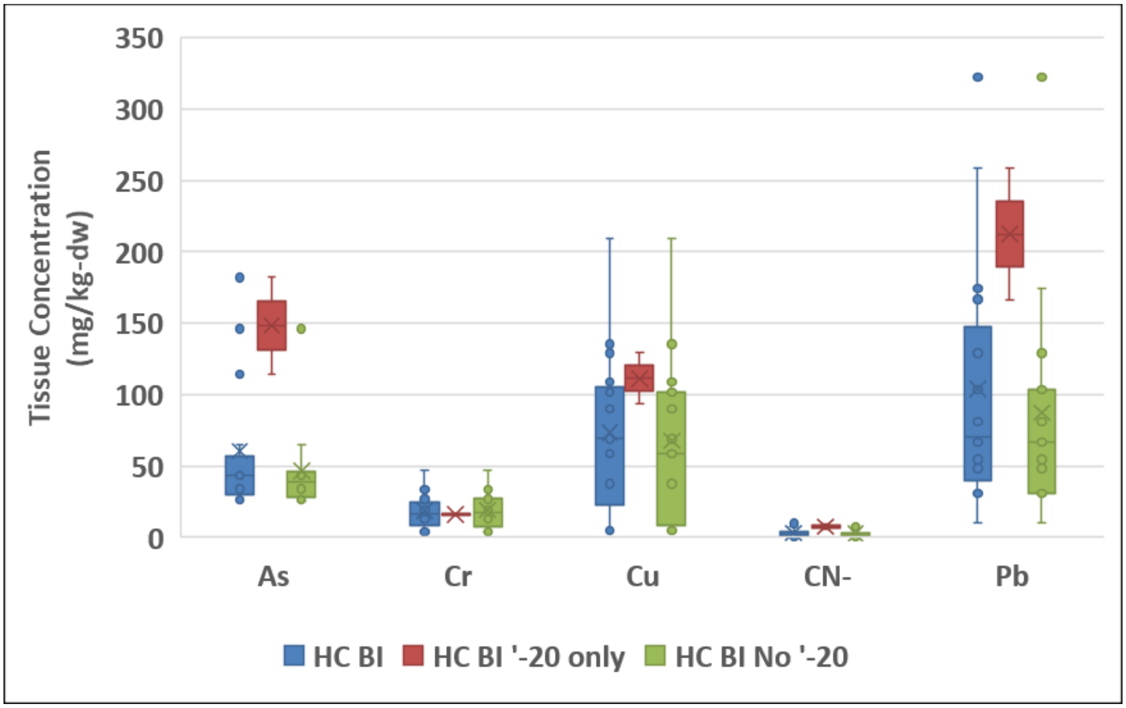

Figure 3 Benthic Invertebrate Tissue Concentrations in HC (UHC + MHC + LHC). As – Arsenic; BI – Benthic Invertebrate; CN- – Cyanide; Cr – Chromium; Cu – Copper; dw – Dry Weight; HC – Hilliards Creek; LHC – Lower Hilliards Creek; MHC – Middle Hilliards Creek; Pb – Lead; UHC – Upper Hilliards Creek.

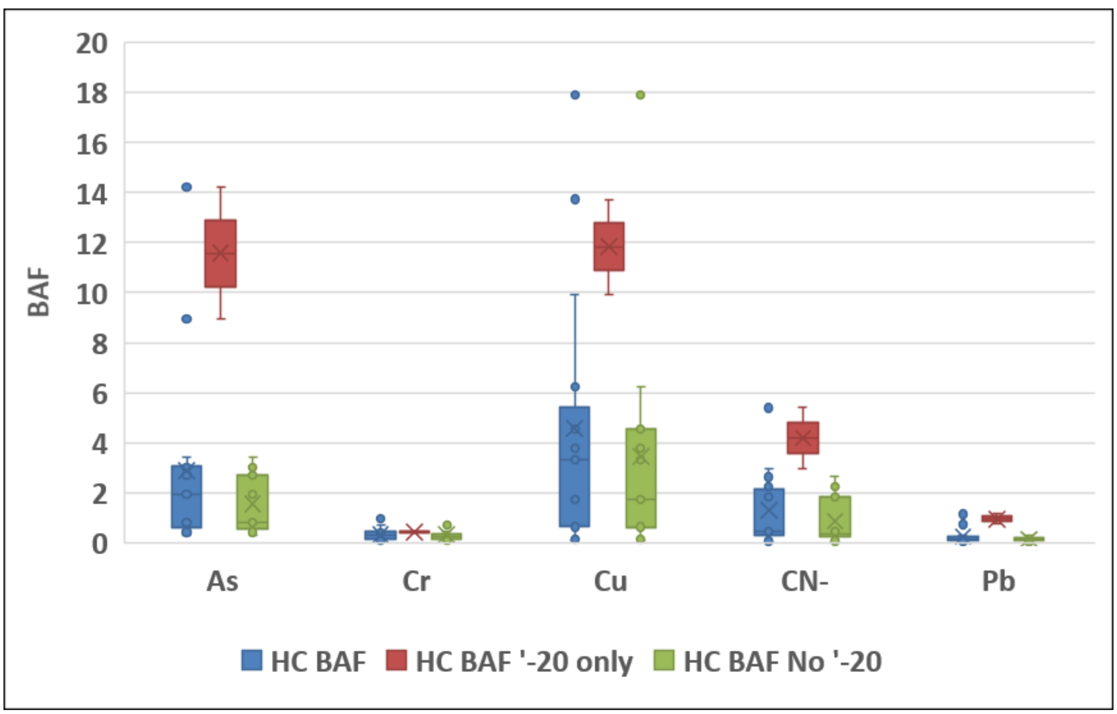

Figure 4 Bioaccumulation Factors in HC (UHC + MHC + LHC). As – Arsenic; BAF – Bioaccumulation Factors; CN- – Cyanide; Cr – Chromium; Cu – Copper; HC – Hilliards Creek; LHC – Lower Hilliards Creek; MHC – Middle Hilliards Creek; Pb – Lead; UHC – Upper Hilliards Creek.

Attachment 1

Statistical Analysis Output

Statistical Analysis Methods and Results

This attachment provides the methods and results of statistical analyses performed in support of the ecological preliminary remediation goal (PRG) development.

Sediment Chemistry and Toxicity Analysis

A statistical comparison was conducted between sediment toxicity test results and sediment chemistry results for the samples collected from HC (Upper Hilliards Creek [UHC], Middle Hilliards Creek [MHC], and Lower Hilliards Creek [LHC]) and the background area. Fifteen locations in HC and ten sediment locations from the background area were assessed for toxicity using a 28-day growth and mortality test using *Hyalella azteca*. In order to test for differences between datasets, the sediment toxicity test responses (*i.e.,* survival, growth, and biomass) were evaluated statistically (using SigmaPlot V13.0). A Kruskal-Wallis one-way analysis of variance (ANOVA) on ranks was performed for each HC sediment bioassay compared to the pooled results for the background samples. The ANOVA was conducted using the data for each replicate tested in the bioassays. Following the ANOVA test and Shapiro-Wilk test for normality, a pairwise multiple comparison (Dunn's Method) was used to identify significant differences between the HC samples and the pooled background samples. The Dunn's test was used due to non-normal data (*i.e.*, failure of the Shapiro-Wilk test) and the unequal group sizes (HC *vs*. pooled background). Further, a Spearman correlation test was used to evaluate the strength of the relationships between each of the toxicity endpoints and the chemical and physical variables in all of the HC 2017 sediment samples. Additionally, a Spearman correlation test was used to evaluate the strength of the relationships between the chemical and physical variables in all of the HC 2017 soil samples. An overall significance level of 0.05 was used for the ANOVA and correlation analysis. The results of this analysis are summarized in Tables A.1 through A.4b, and copies of the statistical output are provided in the following pages.

Kruskal-Wallis One Way Analysis of Variance on Ranks Tuesday, September 25, 2018, 6:48:44 PM

Data source: Data 1 in BKGD comparison_09.25.18

Dependent Variable: Survival

Normality Test (Shapiro-Wilk): Failed (P < 0.050)

Group	**N**	**Missing**	**Median**	**25%**	**75%**
Background	100	0	100.000	90.000	100.000
HCBEDD16-SD-AA-AB-010		0	90.000	90.000	100.000
HCBEDD17-SD-AA-AB-010		0	95.000	87.500	100.000
HCBEDD18-SD-AA-AB-010		0	100.000	90.000	100.000
HCBEDD19-SD-AA-AB-010		0	95.000	87.500	100.000
HCBEDD20-SD-AA-AB-010		0	100.000	90.000	100.000
HCBEDD26-SD-AA-AB-010		0	60.000	37.500	72.500
HCBEDD27-SD-AA-AB-010		0	90.000	82.500	100.000
HCBEDD28-SD-AA-AB-010		0	95.000	90.000	100.000
HCBEDD29-SD-AA-AB-010		0	90.000	70.000	100.000
HCBEDD30-SD-AA-AB-010		0	100.000	87.500	100.000
HCBEDD26-SD-AA-AB-110		0	60.000	50.000	62.500
HCBEDD23-SD-AA-AB-010		0	10.000	0.000	30.000
HCBEDD24-SD-AA-AB-010		0	90.000	90.000	100.000
HCBEDD25-SD-AA-AB-010		0	70.000	60.000	90.000
HCBEDD21-SD-AA-AB-010		0	0.000	0.000	0.000
HCBEDD22-SD-AA-AB-010		0	100.000	90.000	100.000

H = 131.615 with 16 degrees of freedom (P = <0.001).

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001).

To isolate the group or groups that differ from the others, use a multiple comparison procedure.

Multiple Comparisons *versus* Control Group (Dunn's Method):

Comparison	**Diff of Ranks**	**Q**	**P**	**P<0.050**
HCBEDD21-SD-A vs Background	156.220	6.264	<0.001	Yes
HCBEDD23-SD-A vs Background	147.770	5.925	<0.001	Yes
HCBEDD26-SD-A vs Background	127.020	5.093	<0.001	Yes
HCBEDD26-SD-A vs Background	121.020	4.852	<0.001	Yes
HCBEDD25-SD-A vs Background	101.320	4.062	<0.001	Yes
HCBEDD29-SD-A vs Background	40.220	1.613	1.000	No
HCBEDD27-SD-A vs Background	35.720	1.432	1.000	Do Not Test
HCBEDD24-SD-A vs Background	26.670	1.069	1.000	Do Not Test
HCBEDD17-SD-A vs Background	22.670	0.909	1.000	Do Not Test
HCBEDD16-SD-A vs Background	22.520	0.903	1.000	Do Not Test
HCBEDD19-SD-A vs Background	21.270	0.853	1.000	Do Not Test
HCBEDD28-SD-A vs Background	17.120	0.686	1.000	Do Not Test
HCBEDD18-SD-A vs Background	7.570	0.304	1.000	Do Not Test
HCBEDD20-SD-A vs Background	3.420	0.137	1.000	Do Not Test
HCBEDD30-SD-A vs Background	2.170	0.0870	1.000	Do Not Test
HCBEDD22-SD-A vs Background	1.980	0.0794	1.000	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Kruskal-Wallis One Way Analysis of Variance on Ranks Tuesday, September 25, 2018, 6:51:00 PM

Data source: Data 1 in BKGD comparison_09.25.18

Dependent Variable: Weight

Normality Test (Shapiro-Wilk): Failed (P < 0.050)

Group	**N**	**Missing**	**Median**	**25%**	**75%**
Background	100	0	0.254	0.220	0.282
HCBEDD16-SD-AA-AB-010		0	0.353	0.309	0.455
HCBEDD17-SD-AA-AB-010		0	0.473	0.433	0.508
HCBEDD18-SD-AA-AB-010		0	0.466	0.442	0.513
HCBEDD19-SD-AA-AB-010		0	0.397	0.373	0.440
HCBEDD20-SD-AA-AB-010		0	0.458	0.430	0.513
HCBEDD26-SD-AA-AB-010		0	0.625	0.520	0.752
HCBEDD27-SD-AA-AB-010		0	0.417	0.359	0.514
HCBEDD28-SD-AA-AB-010		0	0.459	0.332	0.516
HCBEDD29-SD-AA-AB-010		0	0.456	0.426	0.516
HCBEDD30-SD-AA-AB-010		0	0.471	0.418	0.492
HCBEDD26-SD-AA-AB-110		0	0.692	0.619	0.782
HCBEDD23-SD-AA-AB-010		0	0.413	0.000	0.605
HCBEDD24-SD-AA-AB-010		0	0.390	0.319	0.469
HCBEDD25-SD-AA-AB-010		0	0.464	0.394	0.558
HCBEDD21-SD-AA-AB-010		0	0.000	0.000	0.000
HCBEDD22-SD-AA-AB-010		0	0.458	0.368	0.519

H = 182.310 with 16 degrees of freedom (P = <0.001).

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001).

To isolate the group or groups that differ from the others, use a multiple comparison procedure.

Multiple Comparisons *versus* Control Group (Dunn's Method) :

Comparison	**Diff of Ranks**	**Q**	**P**	**P<0.050**
HCBEDD26-SD-A vs Background	179.730	7.206	<0.001	Yes
HCBEDD26-SD-A vs Background	166.630	6.681	<0.001	Yes
HCBEDD17-SD-A vs Background	120.530	4.833	<0.001	Yes
HCBEDD30-SD-A vs Background	117.680	4.718	<0.001	Yes
HCBEDD29-SD-A vs Background	116.480	4.670	<0.001	Yes
HCBEDD20-SD-A vs Background	116.280	4.662	<0.001	Yes
HCBEDD25-SD-A vs Background	114.980	4.610	<0.001	Yes
HCBEDD18-SD-A vs Background	112.880	4.526	<0.001	Yes
HCBEDD22-SD-A vs Background	110.280	4.422	<0.001	Yes
HCBEDD27-SD-A vs Background	102.480	4.109	<0.001	Yes
HCBEDD28-SD-A vs Background	100.780	4.041	<0.001	Yes
HCBEDD19-SD-A vs Background	84.880	3.403	0.011	Yes
HCBEDD24-SD-A vs Background	82.030	3.289	0.016	Yes
HCBEDD16-SD-A vs Background	75.980	3.046	0.037	Yes
HCBEDD21-SD-A vs Background	62.070	2.489	0.205	No
HCBEDD23-SD-A vs Background	57.630	2.311	0.334	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Kruskal-Wallis One Way Analysis of Variance on Ranks Tuesday, September 25, 2018, 6:49:44 PM

Data source: Data 1 in BKGD comparison_09.25.18

Dependent Variable: Biomass

Normality Test (Shapiro-Wilk): Failed (P < 0.050)

Group	N	Missing	Median	25%	75%
Background	100	0	0.242	0.214	0.264
HCBEDD16-SD-AA-AB-010		0	0.345	0.278	0.430
HCBEDD17-SD-AA-AB-010		0	0.445	0.373	0.472
HCBEDD18-SD-AA-AB-010		0	0.446	0.423	0.460
HCBEDD19-SD-AA-AB-010		0	0.393	0.313	0.420
HCBEDD20-SD-AA-AB-010		0	0.434	0.419	0.494
HCBEDD26-SD-AA-AB-010		0	0.356	0.231	0.406
HCBEDD27-SD-AA-AB-010		0	0.382	0.320	0.400
HCBEDD28-SD-AA-AB-010		0	0.417	0.313	0.466
HCBEDD29-SD-AA-AB-010		0	0.400	0.334	0.446
HCBEDD30-SD-AA-AB-010		0	0.451	0.381	0.486
HCBEDD26-SD-AA-AB-110		0	0.403	0.387	0.422
HCBEDD23-SD-AA-AB-010		0	0.0595	0.000	0.140
HCBEDD24-SD-AA-AB-010		0	0.362	0.308	0.423
HCBEDD25-SD-AA-AB-010		0	0.343	0.278	0.384
HCBEDD21-SD-AA-AB-010		0	0.000	0.000	0.000
HCBEDD22-SD-AA-AB-010		0	0.439	0.368	0.489

H = 182.487 with 16 degrees of freedom (P = <0.001).

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001).

To isolate the group or groups that differ from the others, use a multiple comparison procedure.

Multiple Comparisons *versus* Control Group (Dunn's Method) :

Comparison	Diff of Ranks	Q	P	P<0.050
HCBEDD20-SD-A vs Background	138.850	5.567	<0.001	Yes
HCBEDD30-SD-A vs Background	136.250	5.463	<0.001	Yes
HCBEDD17-SD-A vs Background	133.500	5.353	<0.001	Yes
HCBEDD22-SD-A vs Background	129.350	5.186	<0.001	Yes
HCBEDD18-SD-A vs Background	129.000	5.172	<0.001	Yes
HCBEDD28-SD-A vs Background	112.050	4.493	<0.001	Yes
HCBEDD29-SD-A vs Background	111.750	4.481	<0.001	Yes
HCBEDD26-SD-A vs Background	101.700	4.078	<0.001	Yes
HCBEDD19-SD-A vs Background	96.200	3.857	0.002	Yes
HCBEDD27-SD-A vs Background	94.400	3.785	0.002	Yes
HCBEDD24-SD-A vs Background	90.700	3.637	0.004	Yes
HCBEDD16-SD-A vs Background	86.450	3.466	0.008	Yes
HCBEDD25-SD-A vs Background	73.800	2.959	0.049	Yes
HCBEDD21-SD-A vs Background	70.650	2.833	0.074	No
HCBEDD26-SD-A vs Background	64.600	2.590	0.154	Do Not Test
HCBEDD23-SD-A vs Background	53.850	2.159	0.493	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Spearman Rank Order Correlation Tuesday, April 17, 2018, 1:33:23 PM

Data source: Hilliards Creek Sediment Correlations

Cell Contents:
Correlation Coefficient
P Value
Number of Samples

	Weight	**Biomass**	**SEM/AVS**	**TOC**	**Al**	**Sb**	**As**	**Ba**	**Be**	**Cd**	**Cr**	**Co**	**Cu**	**CN-**	**Fe**	**Pb**	**Mn**	**Hg**	**Ni**	**Se**	**Ag**	**Tl**	**V**	**Zn**
Survival	-0.424 0.125 14	0.788 0.0000868 14	-0.366 0.176 15	-0.405 0.131 15	-0.231 0.396 15	0.204 0.457 15	-0.423 0.113 15	-0.552 0.0312 15	0.33 0.224 15	-0.235 0.388 15	-0.527 0.0413 15	0.117 0.667 15	-0.471 0.0732 15	-0.513 0.048 15	-0.0735 0.783 15	-0.6 0.0175 15	-0.0224 0.934 15	-0.233 0.396 15	-0.0898 0.743 15	0.275 0.312 15	0.116 0.676 15	0.206 0.449 15	0.452 0.0861 15	-0.086 0.753 15
Weight		-0.0792 0.773 14	0.141 0.615 14	0.13 0.648 14	0.167 0.552 14	0.11 0.693 14	0.216 0.444 14	0.378 0.173 14	0.044 0.868 14	0.0198 0.94 14	0.323 0.251 14	-0.0639 0.82 14	0.535 0.047 14	0.198 0.482 14	0.139 0.626 14	0.398 0.152 14	-0.33 0.238 14	0.381 0.173 14	0.286 0.308 14	-0.262 0.356 14	-0.302 0.286 14	-0.132 0.637 14	-0.189 0.501 14	0.0924 0.738 14
Biomass			-0.0593 0.832 14	-0.367 0.189 14	-0.0989 0.727 14	0.416 0.134 14	-0.376 0.178 14	-0.424 0.125 14	0.446 0.105 14	-0.0022 0.988 14	-0.442 0.109 14	0.0792 0.773 14	-0.152 0.594 14	-0.495 0.069 14	0.0769 0.785 14	-0.512 0.0585 14	-0.191 0.501 14	0.124 0.659 14	-0.0594 0.832 14	0.156 0.583 14	0.253 0.373 14	0.225 0.425 14	0.437 0.113 14	0.218 0.444 14
SEM/AVS				-0.368 0.171 15	-0.254 0.353 15	-0.0465 0.863 15	0.0893 0.743 15	0.05 0.852 15	-0.327 0.224 15	-0.161 0.558 15	0.157 0.566 15	-0.513 0.048 15	-0.182 0.506 15	0.0643 0.812 15	-0.293 0.281 15	0.289 0.287 15	-0.306 0.257 15	-0.0466 0.863 15	-0.508 0.0517 15	0.341 0.209 15	0.109 0.686 15	-0.162 0.558 15	-0.525 0.0429 15	-0.225 0.41 15
TOC					0.804 0.0000002 15	0.0572 0.832 15	0.557 0.0299 15	0.636 0.0104 15	0.252 0.353 15	0.7 0.00326 15	0.379 0.158 15	0.447 0.0917 15	0.696 0.00352 15	0.382 0.154 15	0.718 0.00215 15	0.414 0.12 15	0.588 0.0201 15	0.353 0.189 15	0.698 0.00352 15	-0.185 0.498 15	-0.202 0.457 15	0.312 0.252 15	0.3 0.269 15	0.546 0.0339 15
Al						-0.0948 0.724 15	0.575 0.0241 15	0.65 0.00832 15	0.429 0.107 15	0.871 0.0000002 15	0.271 0.319 15	0.338 0.209 15	0.711 0.00256 15	0.0786 0.773 15	0.832 0.0000002 15	0.311 0.252 15	0.399 0.134 15	0.113 0.676 15	0.708 0.00278 15	0.192 0.481 15	0.231 0.396 15	0.706 0.00278 15	0.395 0.138 15	0.607 0.0158 15
Sb							-0.093 0.734 15	0.134 0.62 15	0.216 0.433 15	0.118 0.667 15	0.123 0.648 15	-0.0143 0.954 15	0.152 0.575 15	0.469 0.0757 15	0.166 0.54 15	-0.0143 0.954 15	0.109 0.686 15	0.76 0.00048 15	-0.0591 0.822 15	-0.138 0.611 15	-0.312 0.252 15	-0.0881 0.743 15	0.143 0.602 15	0.526 0.0429 15
As								0.718 0.00215 15	-0.132 0.629 15	0.589 0.0201 15	0.757 0.000575 15	-0.0483 0.852 15	0.739 0.00116 15	0.346 0.199 15	0.507 0.0517 15	0.779 0.0000944 15	0.193 0.481 15	0.0682 0.802 15	0.275 0.312 15	0.0933 0.734 15	0.232 0.396 15	0.285 0.293 15	-0.327 0.224 15	0.368 0.171 15
Ba									0.109 0.686 15	0.639 0.00988 15	0.818 0.0000002 15	0.136 0.62 15	0.736 0.0013 15	0.686 0.00439 15	0.643 0.00934 15	0.782 0.0000337 15	0.284 0.293 15	0.439 0.0975 15	0.354 0.189 15	-0.0556 0.832 15	0.105 0.695 15	0.294 0.281 15	-0.17 0.532 15	0.529 0.0413 15
Be										0.259 0.339 15	-0.324 0.23 15	0.447 0.0917 15	0.127 0.639 15	-0.247 0.367 15	0.42 0.113 15	-0.243 0.374 15	0.418 0.117 15	0.0934 0.734 15	0.445 0.0917 15	0.127 0.639 15	0.0519 0.842 15	0.548 0.0339 15	0.561 0.0287 15	0.213 0.433 15
Cd											0.368 0.171 15	0.315 0.246 15	0.754 0.000677 15	0.232 0.396 15	0.754 0.000677 15	0.293 0.281 15	0.47 0.0732 15	0.251 0.359 15	0.589 0.0201 15	0.0395 0.883 15	0.415 0.12 15	0.517 0.0463 15	0.268 0.325 15	0.843 0.0000002 15
Cr												-0.164 0.549 15	0.604 0.0166 15	0.757 0.000575 15	0.314 0.246 15	0.921 0.0000002 15	0.00357 0.985 15	0.43 0.104 15	-0.0501 0.852 15	-0.233 0.396 15	0.0357 0.893 15	-0.0808 0.763 15	-0.567 0.0263 15	0.307 0.257 15
Co													0.273 0.312 15	-0.0393 0.883 15	0.558 0.0299 15	-0.206 0.449 15	0.68 0.00504 15	0.155 0.575 15	0.739 0.00116 15	-0.295 0.275 15	0.059 0.822 15	0.0314 0.903 15	0.67 0.00575 15	0.4 0.134 15
Cu														0.418 0.117 15	0.693 0.0038 15	0.586 0.0211 15	0.198 0.465 15	0.439 0.0975 15	0.615 0.0143 15	-0.213 0.433 15	0.0929 0.734 15	0.205 0.457 15	0.025 0.923 15	0.711 0.00256 15
CN-															0.161 0.558 15	0.657 0.00739 15	0.143 0.602 15	0.683 0.00471 15	-0.0358 0.893 15	-0.371 0.167 15	-0.279 0.306 15	-0.26 0.339 15	-0.374 0.162 15	0.4 0.134 15
Fe																0.286 0.293 15	0.479 0.0685 15	0.335 0.214 15	0.676 0.00539 15	0.149 0.584 15	0.129 0.639 15	0.506 0.0517 15	0.531 0.0397 15	0.7 0.00326 15
Pb																	-0.00894 0.964 15	0.287 0.293 15	-0.0483 0.852 15	-0.0717 0.793 15	-0.111 0.686 15	-0.0736 0.783 15	-0.606 0.0158 15	0.132 0.629 15
Mn																		0.0539 0.842 15	0.47 0.0732 15	-0.0952 0.724 15	0.0626 0.812 15	0.137 0.62 15	0.362 0.18 15	0.386 0.15 15
Hg																			0.143 0.602 15	-0.51 0.0498 15	-0.354 0.189 15	-0.179 0.514 15	0.0862 0.753 15	0.583 0.022 15
Ni																				-0.137 0.62 15	0.0591 0.822 15	0.39 0.146 15	0.645 0.00882 15	0.562 0.0287 15
Se																					0.208 0.449 15	0.551 0.0325 15	0.133 0.629 15	-0.127 0.639 15
Ag																						0.443 0.0946 15	-0.00894 0.964 15	0.25 0.359 15
Tl																							0.428 0.107 15	0.291 0.287 15
V																								0.386 0.15 15
Zn																								

The pair(s) of variables with positive correlation coefficients and P values below 0.050 tend to increase together. For the pairs with negative correlation coefficients and P values below 0.050, one variable tends to decrease while the other increases. For pairs with P values greater than 0.050, there is no significant relationship between the two variables.

Spearman Rank Order Correlation Wednesday, February 20, 2019, 4:34:12 PM

Data source: Hilliards Creek Soil Correlations

Cell Contents:
Correlation Coefficient
P Value
Number of Samples

	TOC	Al	Sb	As	Ba	Be	Cd	Cr	Co	Cu	CN	Fe	Pb	Mn	Hg	Ni	Se	Ag	Tl	V	Zn
TOC		0.404	0.538	0.143	0.225	0.414	0.2	0.325	0.248	0.318	0.318	0.179	0.179	0.0893	0.275	0.468	0.663	0.492	-0.178	0.514	0.221
		0.131	0.0367	0.602	0.41	0.12	0.465	0.23	0.359	0.24	0.24	0.514	0.514	0.743	0.312	0.0757	0.00654	0.0597	0.514	0.048	0.418
		15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Al			0.681	0.629	0.621	0.929	0.65	0.796	0.724	0.69	0.661	0.7	0.682	0.629	0.715	0.735	0.45	0.653	0.102	0.821	0.657
			0.00471	0.0116	0.0129	0.0000002	0.00832	0.0000002	0.00178	0.00409	0.00695	0.00326	0.00471	0.0116	0.00235	0.0013	0.0889	0.00785	0.705	0.0000002	0.00739
			15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Sb				0.849	0.786	0.633	0.81	0.811	0.81	0.752	0.878	0.829	0.738	0.754	0.804	0.909	0.615	0.895	0.308	0.813	0.82
				0.0000002	0.0000002	0.011	0.0000002	0.0000002	0.0000002	0.000677	0.0000002	0.0000002	0.00116	0.000677	0.0000002	0.0000002	0.0143	2E-07	0.257	0.0000002	0.0000002
				15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
As					0.85	0.629	0.925	0.829	0.931	0.767	0.896	0.925	0.854	0.925	0.819	0.881	0.306	0.757	0.4	0.721	0.879
					0.0000002	0.0116	0.0000002	0.0000002	0.0000002	0.000308	0.0000002	0.0000002	0.0000002	0.0000002	0.0000002	0.0000002	0.257	0.000575	0.134	0.00196	0.0000002
					15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Ba						0.586	0.832	0.914	0.831	0.917	0.879	0.711	0.893	0.839	0.888	0.779	0.414	0.76	0.214	0.679	0.875
						0.0211	0.0000002	0.0000002	0.0000002	0.0000002	0.0000002	0.00256	0.0000002	0.0000002	0.0000002	0.0000944	0.12	0.00048	0.433	0.00504	0.0000002
						15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Be							0.643	0.796	0.758	0.568	0.618	0.693	0.679	0.604	0.584	0.74	0.323	0.542	0.0467	0.7	0.525
							0.00934	0.0000002	0.000575	0.0263	0.0136	0.0038	0.00504	0.0166	0.0211	0.00116	0.235	0.0353	0.863	0.00326	0.0429
							15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Cd								0.779	0.885	0.76	0.8	0.814	0.936	0.896	0.835	0.881	0.38	0.719	0.564	0.689	0.761
								0.0000944	0.0000002	0.00048	0.0000002	0.0000002	0.0000002	0.0000002	0.0000002	0.0000002	0.158	0.00215	0.0275	0.00409	0.00048
								15	15	15	15	15	15	15	15	15	15	15	15	15	15
Cr									0.869	0.863	0.879	0.764	0.843	0.818	0.879	0.833	0.41	0.762	0.0862	0.721	0.843
									0.0000002	0.0000002	0.0000002	0.000391	0.0000002	0.0000002	0.0000002	0.0000002	0.124	0.00048	0.753	0.00196	0.0000002
									15	15	15	15	15	15	15	15	15	15	15	15	15
Co										0.728	0.819	0.87	0.817	0.91	0.771	0.941	0.241	0.658	0.303	0.679	0.831
										0.00161	0.0000002	0.0000002	0.0000002	0.0000002	0.000231	0.0000002	0.374	0.00739	0.263	0.00504	0.0000002
										15	15	15	15	15	15	15	15	15	15	15	15
Cu											0.819	0.651	0.819	0.761	0.914	0.728	0.559	0.84	0.211	0.772	0.899
											0.0000002	0.00832	0.0000002	0.00048	0.0000002	0.00161	0.0299	2E-07	0.441	0.000231	0.0000002
											15	15	15	15	15	15	15	15	15	15	15
CN												0.861	0.793	0.804	0.881	0.797	0.457	0.826	0.151	0.818	0.904
												0.0000002	0.0000002	0.0000002	0.0000002	0.0000002	0.0834	2E-07	0.584	0.0000002	0.0000002
												15	15	15	15	15	15	15	15	15	15
Fe													0.707	0.843	0.695	0.808	0.335	0.726	0.302	0.725	0.811
													0.00278	0.0000002	0.00352	0.0000002	0.214	0.00178	0.269	0.00178	0.0000002
													15	15	15	15	15	15	15	15	15
Pb														0.818	0.865	0.786	0.387	0.719	0.359	0.696	0.736
														0.0000002	0.0000002	0.0000002	0.15	0.00215	0.18	0.00352	0.0013
														15	15	15	15	15	15	15	15
Mn															0.826	0.845	0.349	0.608	0.406	0.582	0.839
															0.0000002	0.0000002	0.194	0.0158	0.127	0.022	0.0000002
															15	15	15	15	15	15	15
Hg																0.793	0.519	0.808	0.283	0.786	0.895
																0.0000002	0.0463	2E-07	0.3	0.0000002	0.0000002
																15	15	15	15	15	15
Ni																	0.436	0.744	0.382	0.751	0.797
																	0.101	0.00103	0.154	0.000786	0.0000002
																	15	15	15	15	15
Se																		0.588	0.0297	0.568	0.421
																		0.0201	0.913	0.0263	0.113
																		15	15	15	15
Ag																			0.253	0.846	0.818
																			0.353	0.0000002	0.0000002
																			15	15	15
Tl																				0.138	0.199
																				0.611	0.465
																				15	15
V																					0.793
																					0.0000002
																					15
Zn																					

The pair(s) of variables with positive correlation coefficients and P values below 0.050 tend to increase together. For the pairs with negative correlation coefficients and P values below 0.050, one variable tends to decrease while the other increases. For pairs with P values greater than 0.050, there is no significant relationship between the two variables.

Table D-3A
Former Main Plant
Soil Alternative 3A - Soil and LNAPL Removal/Treatment, Capping with Supplemental Excavation and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
Predesign					
	Supplemental Investigation	1	LS	$35,000	$35,000
	Subtotal				**$35,000**
Project Management and Mobilization					
	Project Management and Coordination	1	LS	$185,000	$185,000
	Mobilization/Demobilization	1	LS	$155,000	$155,000
	Site Preparation, Clearing, Erosion Controls	1	LS	$30,000	$30,000
	Field Office	18	Months	$4,000	$72,000
	Temporary access roads	0	LF	$380	$0
	Traffic Control	60	Week	$3,000	$180,000
	Temporary Fencing	0	LF	$6	$0
	Sampling - (Waste Characterization: Collection and Analysis)	41	Sample	$1,200	$49,732
	Sampling - (Post-Excavation: Collection and Analysis)	412	Sample	$400	$164,889
	Subtotal				**$836,621**
Demolition Activities					
	Building Demolition	0	LS	$50,000	$0
	Concrete Demolition and Crushing	465	CY	$70	$32,550
	Asphalt Demolition	149,100	SF	$1	$149,100
	Concrete Transportation and Recycling	698	Ton	$20	$13,950
	Asphalt Transporation and Recycling	4142	Ton	$20	$82,833
	Well Abandonment	14	Well	$900	$12,600
	Fence Removal	0	LF	$3	$0
	Subtotal				**$291,033**
Water Management					
	Groundwater Management	1	LS	$40,000	$40,000
	Surface Water Management	1	LS	$15,000	$15,000
	Water Transportation and Disposal	50,000	Gallons	$0.56	$28,000
	Subtotal				**$83,000**
Soil Excavation and Disposal					
	Utility Protection/Management	1	LS	$20,000	$20,000
	Structural Support/Shoring	22,522	SF	$27	$606,829
	Conveyance Pipe Removal	0	LS	$30,000	$0
	Soil Excavation (Upland Areas)	35,634	CY	$10	$356,340
	Soil Excavation (Wetland/Riparian Areas)	0	CY	$20	$0
	Soil Stabilization (Wet Soils)	2,361	Ton	$26	$61,386
	Soil T&D (Non-hazardous)	52,576	Ton	$60	$3,154,566
	Soil T&D (TSCA)	1,300	Ton	$240	$312,000
	Subtotal				**$4,511,121**
Capping, Backfill and Restoration					
	Geotextile Fabric	207,151	SF	$0.36	$74,137
	Structural Backfill (Furnished, placed, compacted)	53,451	Ton	$20	$1,069,020
	Asphalt Paving	149,100	SF	$4	$596,400
	Concrete Paving	15,783	SF	$6	$94,698
	Topsoil	1,062	Ton	$30	$31,848
	Landscape Restoration	0.95	Acres	$20,000	$18,924
	Conveyance Pipe Restoration (60" RCP)	0	LF	$200	$0
	Manhole Restoration	0	Each	$3,000	$0
	Fence Restoration	0	LF	$40	$0
	Wetlands Restoration	0	Acres	$328,225	$0
	Monitoring Well Replacement	14	Well	$7,000	$98,000
	Institutional Controls	1	Each	$10,000	$10,000
	Subtotal				**$1,993,027**
	Total Costs W/O Management and Engineering				**$7,749,803**
Management and Engineering					
	Engineering/Legal Admin			16%	$1,239,968
	Subtotal				**$8,989,771**
Contingency				10%	$898,977
	Total Capital Cost				**$9,888,748**
Operation/Maintenance					
Annual O&M					
	Quarterly Inspection/Maintenance	1.0	$/Year	$10,000	$10,000
	Contingency			10%	$1,000
	Total Annual O&M				**$11,000**
	Present Worth Annual O&M Cost for 30 years @7%				**$136,499**
Periodic O&M					
	CERCLA Five Year Review	1	Each	$12,000	$12,000
	Contingency			10%	$1,200
	Subtotal				**$13,200**
	Present Worth Periodic O&M Cost for 30 years @7%			7%	**$28,483**
			Total Estimated Cost (Capital and PW O&M)		**$10,053,731**